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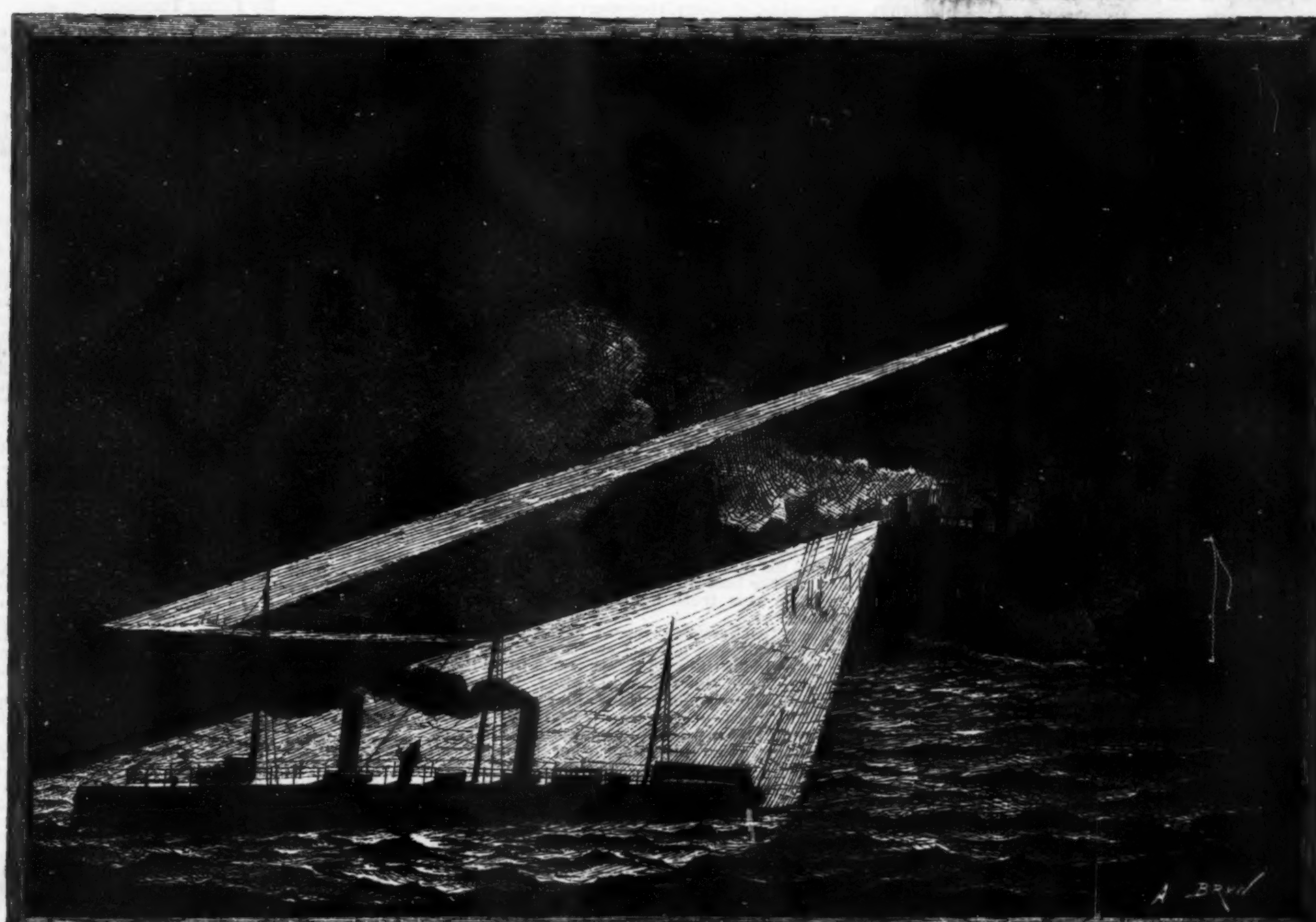
SURPRISE OF ITALIAN TORPEDO BOATS.

On the 11th of August, during the grand naval maneuvers of the Mediterranean, an incident occurred that has been variously commented upon by the newspapers and that has been inaccurately reported. The following are the facts as they have been given us by an eyewitness: The squadron was moving up along the east coast of Corsica and was abreast of Bastia. It was well into night when the Tage, a cruiser of the first class, which stood to the seaward of the coast squadron, discovered by the aid of its projector a small ship without signal lights or distinctive signs of any sort. It was situated between the line of our cruisers and that of our ironclads. As it resembled none of our own and was, moreover, cleared for action, it was kept in the field of the light and attentively observed, while at the same time the horizon was swept with a second projector placed in the tops of the mizzenmast. This examination brought to light four other ships. When the latter saw that they were discovered, they displayed their lights. They were Italian torpedo boats that had found it interesting to follow our maneuvers and inform themselves as to our night tactics.

The first seen, and the one that was nearest the squadron, was recognized as the Sparviero, a torpedo boat 47 meters in length and of 160 tons displacement, and the engine of which develops 2,200 horse power. This vessel, it is said, made 26 knots originally, but this speed has since sensibly diminished.

The statement that persons were seen upon the deck of the torpedo boats is inexact, but the presence of this small squadron in our waters at the moment of our maneuvers rightly seemed suspicious, and Admiral Vignes hastened to refer the matter to the Minister of the Marine.—*L'Illustration.*



SURPRISE OF ITALIAN TORPEDO BOATS BY A FRENCH WAR SHIP.

A PRESENT DUTY.*

By Edward Baxter,

I appreciate highly the honor you have conferred upon me by inviting me to address you upon the important question which you have met to consider.

It is proper, however, that there should be no misapprehension as to the character in which I appear before you.

I do not represent the management of the Louisville and Nashville Railroad Company. I am not authorized to speak for the executive officers of the company. I have had no consultation with them upon the subject which you now have under consideration. I have had no correspondence with them upon the subject, except to receive a very unexpected letter reducing my salary 20 per cent.

I do not own any of the company's bonds.

I do not own any of its stock.

I have no interest in the company, except to work for it, for pay, as you do.

My family is dependent upon my daily labor for support, just as your families are dependent upon your daily labor. I have no income of any consequence outside of my profession. The reduction of my salary was as severe a blow to me as the proposed reduction of 10 per cent. in your wages can possibly be to you.

I had entered into important contracts, relying upon the continuance of my salary, and I have not been able to see how I shall meet the pecuniary obligations which I have assumed under those contracts. But one thing is perfectly plain to me, and that is, that I cannot possibly pay my debts by stopping work.

In deciding whether I would submit to the reduction in my salary, I had to consider the same question which is now presented to you. In considering the question, I was able to look alone to the interest of myself and my family. The interests of the public were in nowise involved in my decision. It is a matter of no concern to the public whether I continue to work for the company or not; but when you come to consider the question as to whether you will stop working for the company, you are morally bound to consider the interests of the public as well as the interests of yourselves and your families.

The locomotive engineer is as essential to the public as he is to a railroad company. Not an engine or car can be moved without him. If he stops, the mails must stop, the express business must stop, the transportation of freight and passengers must stop, and the entire internal commerce of the country must be paralyzed. If all the railroad attorneys in the United States should stop to-day, it would not affect the public interests in the least. But if all the locomotive engineers in the United States should stop work to-day, the internal commerce of a continent would be instantly suspended, and the loss to the country would amount to millions of dollars a day.

Your occupation is one in which the public has a vital interest; and the public will hold you morally responsible for the manner in which you conduct yourselves in matters which affect the public.

If I refuse to submit to the reduction in my salary, I will be thrown out of all employment, at least until I can build up another practice. No other company in a time of such depression would pay me any more than my reduced salary; and probably I could not find any immediate employment at all. I must therefore accept the reduction or go out upon a strike all by myself.

In other words, I must stop work and become a loafer. If I stop work, I must borrow, beg or steal, or my family will suffer for the absolute necessaries of life.

It is true that your brotherhood has a fund from which it can aid you temporarily, if you see proper to strike; but the monthly donations which you would receive from that fund are much less than your wages would be, even if you accepted the proposed reduction. Besides, the protective fund of your brotherhood is raised by contributions from those members who may continue at work; and while such contributions may be cheerfully made by your brethren, the fact remains that one portion of the brotherhood will have to be taxed to support another portion in idleness so long as the strike may continue.

In times like these every one should economize; and every one can economize to the extent of 10 or even 20 per cent. of his usual income. We can all leave off the luxuries of life, and in some instances it would be a positive benefit to many persons if they should be forced to abandon some of our so-called luxuries.

By leaving off one or two drinks and two or three cigars a day, a man can save 50 cents, which is equal to 10 per cent. on wages of five dollars a day.

We can wear patched clothes and shoes, and when we must buy new clothes we can get cheaper styles than we have heretofore been used to.

If the financial crisis now upon the country shall have the effect to teach us the habits of economy and

* Address delivered before the representatives of the Brotherhood of Locomotive Engineers of the Louisville and Nashville Railroad Company, at Nashville, Tenn., August 25, 1893.

check the reckless extravagance in which the country has been indulging for the last few years, our present affliction will prove to be a "blessing in disguise."

We should all economize, not merely to provide for our own selfish wants, but to enable those who must necessarily be thrown out of employment by the very fact that the community shall have become more economical.

If every one stops the use of cigars, the cigar makers will be thrown out of employment, and the community must take care of them until they can find other means of employment, or until times become better again.

But, while judicious economy should be practiced by all, the man who, like a miser, hoards his money at a time like this does a great injury to society. Such a man is not only extremely selfish, but by locking up his money he diminishes to that extent the circulating medium of the country, and in that way aids in paralyzing the mining, manufacturing, mercantile, agricultural and commercial business of the country. Very little of the business of the country can be transacted without the use of a certain amount of currency; and if each individual locks up his own money, the entire circulating medium of the nation will be at once withdrawn from its usual channels, and business of all kinds will become congested and perish.

But business cannot be carried on with capital alone. It requires a union of labor with capital to conduct any kind of business. It follows that a man who hoards his labor at a time like this does as great an injury to society as he who hoards his capital. The man who quits work voluntarily hoards his labor. The man who refuses to work for the highest wages which the necessities of his employer will enable him to pay, voluntarily quits work and hoards his labor.

In these times every one should keep at work who can find employment, because those who quit work must become burdens upon those who continue to work.

"An idle brain is the devil's workshop." So long as I am at work in any honest occupation I am removed from the allurement of vice. But when I am idle my natural disposition is to get into mischief of some kind.

The unemployed of New York, Buffalo and Chicago have been seduced already into conduct which has brought them into armed conflict with the authorities of the law.

Really, it is better to work for nothing than not to work at all.

If I must starve I would rather starve working than to starve loafing.

Labor strikes have no law to support them. Their only support is public opinion.

In this country every man is legally free to work or free to remain idle; but public opinion denounces as a loafer a man who refuses to work when offered fair wages. In this country every man is legally free to say what wages he will pay for labor; but public opinion denounces as an oppressor a man who refuses to pay fair wages to those whom he employs.

In the case of railroad companies dealing with their employes, public opinion operates with peculiar force and in mysterious ways.

Boycotts are placed upon their traffic. Hostile laws are enacted by the legislatures. Oppressive verdicts are found by the juries, and onerous judgments are rendered by the courts.

No railroad officer is competent to manage the important interests committed to his charge who does not appreciate the force which public opinion exerts, in a thousand ways, upon the railroad companies of this country.

It was charged in the newspapers that a distinguished railroad official once said, "Damn the people!" It was afterward denied that he ever made use of such an expression. But if any railroad officer was ever foolish enough to "damn the people" he was either too ignorant to appreciate the force of public opinion or too reckless to be in charge of the management of railroad property.

If you so conduct yourself as to get and keep public opinion on your side and it should eventually become necessary for you to strike, your strike will be sure to win. On the other hand, if public opinion should be against you, your strike will be sure to lose.

Business is crippled bad enough as it is. Mines and manufactories are stopping everywhere. Hundreds of thousands of poor people are being thrown out of employment. Merchants and bankers are breaking every day. Currency has disappeared from the marts of commerce. The transportation business of the country is almost at a standstill. Everything is in a fearful state of confusion and demoralization. Are you ready and willing to add to the universal distress by stopping the operations of the railroads?

What will the city merchants think of you if you prevent them from selling their goods by stopping the railroad over which they must be shipped?

What will the country merchants think of you if you prevent them from getting their supplies, by stopping the railroads over which they must be transported?

What will the farmers think of you, if you prevent them from shipping to market the wheat and other farm products which they have been holding for better prices?

What will the public at large think of you if the mails and express matter are stopped, and if passenger trains are interfered with, so that people cannot travel about to transact the little business that is left?

How are the hundreds of thousands of unemployed poor people in the cities and towns to be fed if the farm products cannot be moved to them by the railroads?

Business is now like a locomotive engine which is "broken down on one side," and which has a heavy train attached to it. You all know that it cannot make the speed it could make if it were in working order; but you also know that so long as it can keep in motion, though it moves ever so slowly, there is a chance that it can get the train into station. The moment that it comes to a dead stop, however, the difficulty of again starting is increased a thousandfold. Are you prepared to throw the business of this country upon "a dead center" at this time of supreme peril?

If you assume such a fearful responsibility, public opinion will certainly turn against you; and every newspaper in the country will censure you severely. The people who ship freight know that but little freight is moving. They know that the earnings of the railroads have necessarily fallen off. They know that the earnings of a railroad are the only means by which the railroad company can pay the wages of its employes. They know that the expenses of railroad companies must be temporarily reduced while the earnings are so small; and the people will expect you to make some sacrifice rather than stop the transportation business of the country at this time.

My sincere advice to you is to accept the reduction; and to accept it promptly and cheerfully. My advice is to accept it without demanding any conditions. Let the people see that you are as liberal as you are brave. Men who risk their lives every day in the discharge of their duty should not hesitate to bear their share of the burden which is now resting so heavily upon all.

When the earnings of the road shall be restored to what they formerly were, I believe the wages will be restored; but if the management should refuse to restore them, you would then be in a position to appeal to public opinion, with an assurance of absolute certainty that your appeal would not be in vain.

THE ADVANTAGES OF MEMORIZING.

THE favorite books of Tennyson were the Bible and Shakespeare. He once advised a boy to read daily at least one verse of the former and some lines from the latter. "The Bible," he said, "will teach you how to speak to God; Shakespeare will teach you how to speak to your fellows." It is well also to commit to memory many of these and other precious things, and thus make them our own in a way that the mere reading of them can never do.

To what extent should the child memorize? Of all people perhaps teachers are most to be congratulated upon the opportunities their work affords for good to themselves and others. The best thought, most suggestive and most helpful, of the choice spirits of the ages, in its finest expression, is theirs—if they will have it. But is anything more true of thousands of teachers than that, in the midst of plenty, they starve their own souls and those of their pupils? Shall the memory be merely a sort of refuse chamber of odds and ends of personal experience, a junk shop collection of things of little value, or shall it be a treasure chamber filled with things of inestimable value, and radiant with light and beauty?

Let the habit of committing to memory be formed early. Let it be continued through school days and all the after years of life. We shall thus become educated in a high and true sense—fed, for that is what the word means, upon intellectual manna which might well be the food of angels. We shall be educated because widely familiar with the very best prose and verse in the literature of the world, and quickly and gladly responsive to the thought of the author. Not a few of these gems—"their price above rubies"—are short as to number of lines and occupy but little space in print, as "Abou Ben Adhem," "Ozymandias," "Crossing the Bar," and a hundred others.

This habit once acquired and steadily followed is one of the most profitable and enjoyable that can be formed by quiet people who never have occasion to make a public address; while the teachers who must frequently address their schools, to school superintendents, clergymen, lawyers, and public speakers generally it is of immense value. To exercise the memory in the manner suggested is to strengthen it and to keep it strong. The imagination is at the same time cultivated, the vocabulary improved, and the best expression of the best thought of the masters becomes our own; just as the musician thoroughly at one with his art is what he is because of close sympathy with the tone masters, and his perfect knowledge both of the letter and spirit of the best things they have written. Beyond question this truth holds in literature no less than in music.

How many teachers can repeat accurately a half dozen of the Psalms, or a dozen choice poems of moderate length which the world has taken to its heart, or a like number of fine things in prose? How many have their pupils to commit these things to memory? They are the finest of the wheat, and they remain when the chaff and sawdust of non-essentials in arithmetic, grammar, geography, and other branches are utterly blown away. Securely garnered in the memory, these things lift the life by lifting the thought, the love. They elevate the entire being into a finer and purer atmosphere, make distasteful things that are low and mean, present new ideals and new aspirations. Through them more and more we walk by faith in the unseen. And of all education—all feeling of mind and heart from childhood to old age—this is the rarest and the best.

Often a single poem made one's own in youth influences thought and character and affords gratification for a lifetime. A few days since a gentleman remarked in our hearing: "I thank the teacher who made me commit Bryant's 'Thanatopsis' to memory. I didn't want to do it, but he compelled it. I have thanked him ever since, and much more as a man than when a boy." It is quite possible for pupils to do fairly good work in the ordinary branches of school training, and yet to have one or two things like this stand out above everything else, to be remembered for a lifetime with gladness and gratitude. Is there not a suggestion here for the thoughtful teacher?

We like the practical thought of Tennyson, which makes one part of this work all the while moral and religious. Let the selections for the week be, if possible, two in number: the first from the Bible or sacred song, and the second from the world of literature, prose or verse, in other directions—say the ninetieth psalm and "Lincoln's Speech at Gettysburg;" or "Lead, Kindly Light," and Longfellow's "Psalm of Life;" or the twenty-third psalm and Lowell's "Once to Every Man or Nation;" or the nineteenth psalm and "Home, Sweet Home!" or "My Country, 'tis of Thee," and "The Chambered Nautilus;" or the thirteenth chapter of Corinthians and "The Last Rose of Summer;" or any others of hundreds of good things, moral, religious, patriotic, descriptive, or sentimental in the best sense of the word, that we should all be very glad to have securely lodged in the memory. And let the teacher always commit to memory what is here required of the pupil. Should two each week be too many, let the selections alternate, sacred and secular, one each week.

Any good book of varied and choice selections can and should be supplemented by the Bible, and by a manuscript collection of best things dictated by the teacher and written down by the pupil. In our own school two hours on Tuesday morning are given to this exercise. The selections for the week that have been memorized are first written by the pupils, effort being made to reproduce them with spelling, capitals, and punctuation, as found upon the page. The books are then exchanged, the selections read by the teacher, all errors marked by the pupils and the work graded accordingly. The selections for the following week are then announced, read and discussed at such length as time will permit, attention being directed to anything new or of special interest which might be overlooked by the pupil.

Memorize accurately. Get it as the author left it, the exact words he used, and each word in its place. See the capital letters, the spelling and meaning of unusual words, and the punctuation marks, so that you could write it as "copy" for the printer. This requires care, close observation, thought, and encourages the habit of close attention. In committing to memory also try to see the page in your mind as it lay before you.

An aid of some value is to use the pencil and the ordinary "four and tally" count. For each stroke of the pencil held upon it, repeat the sentence, or line, or verse, or selection. This enables the pupil to keep ready count of the number of times he or she has repeated it. For a time the school might do this work aloud and in unison, so that all would fall in with the method. This means close strain upon the attention, but it means definite result as well.

Each pupil should have a blank book in which these things may be written from dictation or copied from the blackboard. Such book will be highly prized in after years.—*Educational Journal.*

HIGH FREQUENCY ELECTRIC INDUCTION.*

By ELIHU THOMSON.

IT is my purpose in the present paper to give an outline of some experimentation with electric currents of high rate of change or high rate of oscillation compared with the rate of ordinary alternating currents. These latter alternate their direction of flow from 100 to 250 times per second, or the current is composed of waves or pulses reversed in direction at that rate. We therefore speak of 100 to 250 alternations; or, as it requires a double reversal to make a complete wave, we speak of a periodicity or frequency of 50 to 125. Fifty waves per second would be a comparatively low frequency current; five thousand to ten thousand, a moderately high frequency; and hundreds of thousands to many millions may be called high and very high frequencies comparatively speaking. Still, all things are relative, and in the light wave or radiant heat wave we have electrical oscillations of frequencies as great as hundreds of millions of millions per second. If we have two conducting plates separated by an insulating space, and charge one plate positively and the other negatively, we have a simple type of what is called a condenser. The insulation may be air or other dielectric, such as glass or hard rubber. We have in the Leyden jar the earliest form of condenser, and for certain purposes still the best form of this useful electrical device. The charged thunder cloud layer separated from the earth by a layer of air forms with the earth surface a huge condenser, and the earth strokes or lightning flashes between earth and cloud are the discharges of such condenser. If in a condenser the charge is sufficiently increased in potential difference between the conducting plates or the plates brought near enough together, or if a wire be run from one plate near to the other, a discharge takes place in the form of a spark and there is also an equalization of charge of the plates. The spark simply indicates a breaking down of the medium separating the plates and its momentary conversion into a conductor composed of hot gases and metallic vapors joining the two plates where the spark existed.

It was formerly thought that in equalizing the charge or combining the positive of one with the negative of the other in such a discharge of a condenser the spark represented a single rush or flow of electricity. Long ago, however, Professor Henry was led to the conclusion that these discharges were of oscillatory character and that the action of discharge resembled that of the release of a bent spring which only comes to rest after a number of more or less rapid alternations or to and fro movements. More recent investigations have settled conclusively the fact that the condenser spark represents in most cases, though not always, an electrical vibration or oscillation of charges, an alternating current of high frequency lasting for a fraction of a second, in which fraction of a second the direction of the current has reversed many times with diminishing force. Prof. J. T. Trowbridge, by means of a rapidly revolving mirror and other ingeniously devised apparatus, has obtained most beautiful photographs of such discharges, showing in the most perfect manner the oscillations of current referred to. Now, if a condenser of a certain capacity, as it is termed, be discharged over a short path, the rate of its oscillations of discharge will be greater than when the path or wire through which it is discharged is long. And if the wire forming the path of discharge be of good conducting material and wound into a simple coil of very many turns, the frequency or rate of oscillation of the current of discharge will be much further lowered. Indeed, in this way it is possible to give to the discharge any desired rate within reasonable limits. From a rate of hundreds of thousands per second it may be brought down to less than one thousand. By the addition of the coil in the discharge circuit we have brought into play a property called inductance, which acts to slow the rate of discharge.

If a current be suddenly passed through a coil of wire, it meets with an opposing force which tends to delay its passage, owing to the fact that around the coil and through its axis there must be some work

* Read March 9, 1893, before the Society of Arts, Boston.—*Tec. Quarterly.*

done in producing magnetism in the medium. On an attempt being made to cut off the current, the magnetism in disappearing sets up an action which tends to prolong the current and prevent its change. These are the actions of self-induction, more recently called inductance. An iron core or bundle of iron wires increases the value of the inductance very greatly.

Early experimenters frequently passed Leyden jar or condenser discharges through coils of wire and noted the effects, the chief of which was to flatten or deaden the sharp snap of the discharge. To-day with a sufficiently long coil we may cause the discharge to take any pitch and become audible, if we please, as a musical tone.

Early experimenters, notably Professor Henry, even placed alongside the coils through which condenser discharges were passed other coils and received the inductive discharges set up in the parallel coil, thus realizing in embryo an induction coil, the primary coil of which was given an oscillating condenser discharge, while the secondary currents obtained in the parallel coil were noted by simple means.

In 1877 I made similar experiments in passing the discharge of a number of large Leyden jars through the primary or secondary of a Ruhmkorff coil and noting the effects in the other coil. The effects were in some cases high frequency effects, though scarcely recognized at that time. But we have in the Ruhmkorff coil itself an excellent example of an apparatus in which a charged condenser discharges at a high rate through a primary coil and induces a very high potential discharge in a long and fine secondary coil placed outside the primary.

It has often been stated in the books that the function of the induction coil condenser, which has its conducting foils respectively connected on each side of the break piece which interrupts the current of the battery passing in the primary coil, is simply to prevent spark at the contacts of the interrupter by absorbing or taking up the extra current which would otherwise appear as spark. This is incomplete and erroneous, as may easily be proved.

The ordinary induction coil has its primary coil, its secondary, interrupting contacts for the primary, condenser around them, and battery with rather short conducting wires, and may be assumed to work normally and give a high potential spark between its separated terminals at every interruption of the primary coil and battery circuit.

Now let us extend the wires of the battery to a very considerable length, or coil them in separate open coils, yet keep them of large enough size so as not to weaken the battery current by increase of resistance in its circuit. On working the coil and adjusting the condenser to get rid of spark, we find the activity of the secondary lessened. It can, however, be restored by connecting a large capacity condenser, or better, a cell with plates of lead immersed in dilute sulphuric acid across the battery wires near the coil. Moreover, for a Ruhmkorff coil to give its maximum effects the condenser chosen for it must have a definite size or capacity depending on the proportions of the primary coil and core and the electromotive force of the battery. The real object of the condenser is to obtain the benefit of a high frequency reversal in the primary coil, that is, to confer the high period oscillatory character of the condenser discharge on the primary current, and so get enormously increased inductive effects in the secondary wire.

This effect of inducing discharge in the secondary wire depends on a magnetic change or loss of magnetism in the iron wire core or bundle in the center of the coil. Upon the interruption of the primary circuit the condenser receives a charge from the primary wire which instantly discharges itself in the reverse direction through the primary, and as a consequence quickly discharges and tends to reverse the magnetic state of the core. The more quickly the reversal takes place, other things being equal, the longer the spark obtainable from the secondary circuit terminals. Lengthening the wires to the battery delays this reversal by interposing more self-induction, which, as stated above, is a cause of reduced speed or rate of oscillation of the condenser discharge.

As, however, when the lead plate cell is used as a shunt to the battery wires near the coil, the reversal may now be confined to a local circuit including only the primary coil and the shunting cell with its lead plates, and it will be seen that the effect of long battery wires may thus be almost completely counteracted. It does not follow that the secondary discharge of a Ruhmkorff coil is oscillatory even when the primary tends to be so, for the very high resistance of the secondary circuit will probably prevent the flow of more than a single pulse of current in one direction at each break of the primary circuit.

Having stated the conditions under which we may expect to work successfully, we may now be prepared to simplify our apparatus. Let us take a Leyden jar, or battery of jars, charged say to give one half inch spark between its terminals, one from the inner coating and one from the outer coating, and interpose a coil of a few turns of wire in the discharge path or circuit. Upon a discharge passing, an exceedingly rapid to and fro current passes in the coil, the turns of which must be kept well apart or a leap from turn to turn will take place in the effort of the current to avoid going around. Now place another coil parallel to the first, and let these be of an equal number of turns, but well insulated from the first. On passing the discharge through the first coil a similar discharge may be obtained between the separated terminals of the secondary coil.

Let the secondary coil be replaced by one of say twenty times the number of turns which the first coil has, and the discharge be sent through the first. In this case it will generally be found that the second coil gives evidence of very powerful induction, but that it requires to be immersed in oil to preserve its insulation. This is done by placing both coils in oil and repeating the experiment. Now the terminals of the secondary coil may yield sparks of several inches in length even though the condenser jars may only give one-half inch. But what have we here? Merely a Ruhmkorff induction coil with a condenser charged to 20,000 volts perhaps, as against one charged in ordinary cases to less than a hundred volts. It is no wonder, then, that we may use a secondary of only a few hundred turns of wire as against one of many thousands of turns in the ordinary Ruhmkorff induction coil and obtain the same or a greater length of spark. I have an apparatus of this kind with ten turns of coarse wire in its primary wound as an open single layer coil, and 300 turns of secondary, also a single layer, both immersed in an oil box. On passing condenser discharges of 20,000 volts in the primary it will give very long sparks from the secondary. The turns of the primary are selected to give the heaviest current and highest rate of oscillation of the discharge with as many turns as possible; in other words, to obtain a convenient maximum. It is inconvenient to charge the condensers and use only a single discharge at a time. To obviate this I have recourse to a modification of a method which I first applied in 1881, that is, to use a dynamo current of alternating character to keep charging the condensers as they are discharged. I found that I could so use the dynamo current as to cause condensers to rapidly charge and discharge over a spark gap, and that a coil in circuit with the condenser needed to have its turns kept apart an eighth of an inch or more, even though the wire was well covered with paraffined cotton. The inductive effect of the coils in the condenser circuits was very high, and I was convinced at the time that we had to deal with discharges of very high rates of change. In applying dynamo currents to the charging of a condenser we may therefore use an alternating current of say 75 volts potential and of low period or low frequency, such as ordinary lighting currents, and by an induction coil or transformer raise such potential to say 20,000 to 30,000 volts in the secondary winding. This high potential current is now used to charge a condenser of suitable capacity, such as a battery of Leyden jars, the discharge circuit of which includes an open coil of but few turns and a space called a spark gap, over which the discharge must leap. An air jet plays upon the spark gap to prevent a continuous arc forming.

To digress for a moment here, it may be mentioned that with a condenser of two or three jars and a properly directed air jet or wind blowing on the spark gap, some of the most beautiful imaginable effects of electrical discharge are obtainable. Appearances of beautiful striated flames and networks of fine sparks surrounded by purple fire are easily obtained. Also by putting in circuit with the condenser and spark gap coils of very many turns of fine wire, the rate of vibration may be so lowered as to obtain discharges which whistle continually like the notes of a canary, or which are still lower in pitch, or again so high that the note, though strong, is at the upper limits of audition.

But to return to the coil of few turns, it will be found that the apparent resistance of even a very coarse wire used in the coil is so great that an incandescent lamp may be lighted between one turn and its neighbor, that, in fact, the opposition to the flow of current is so extraordinary that a considerable length of spark may be obtained in shunt to a few turns. Let us pause to consider why this is. The condenser charge on leaping the spark gap tends to pass a very heavy current through the coil, *i. e.*, to discharge instantly. This involves, however, the instantaneous production of an intense magnetic field in and around the coil, which gives rise to a force tending at first to check the condenser discharge and afterward to prolong such discharge, so that there results an overdischarge or a charge of opposite character which again discharges, and so on. But these oscillatory discharges may have a rate of hundreds of thousands per second, or a still higher rate depending on the conditions. Every inch of wire in the coil is as active as a number of feet at lower frequencies.

One of the most curious effects producible is that of balanced induction, as when a double coil is used one inside of the other, the turns of which can be so selected that all of the discharge passes in the outer coil or all in the inner. A departure from a definite relation of turns, relatively less or more, destroys this balance of induction.

The inductive action of the high frequency discharges in question is quite intense. Electro-dynamic inductions so intense as to generate potentials of a hundred or more volts to the inch of wire, are readily obtained, and of course the reaction or self-induction of such a current sent into a circuit is equally remarkable. Conductors which are so heavy that with ordinary continuous currents an ordinary incandescent lamp would be completely shunted offer such an impedance to these high frequency currents that the lamp is brilliantly lighted across a short heavy loop, an experiment due to Mr. Tesla, an early worker in this field. A single turn of wire of say six or eight inches diameter of circle, used as a secondary to a few turns used as a primary, suffices to brilliantly light a lamp connected in the circuit of the turn. Such experiments may be modified in many ways.

In experimenting with apparatus in which a very few turns of wire were used with the condenser discharge as a primary, and in which a few hundred turns were used as a secondary, it was found to be necessary to immerse the coils in oil to insulate them and prevent escape of the currents induced in the secondary. These experiments have developed the curious fact that while ordinary coils are capable of resisting puncture by high potentials of ordinary alternating currents when the thickness of the insulating layer of oil is to the air layer as about 1 : 3 or 1 : 4, the relation when high frequency currents are used is about 1 : 40. It was also found that the cleaner the oil or more free from suspended particles, the more uniform its insulating power or resistance to puncture and the greater the potential needed to puncture it. Another curious fact was brought out, namely, that under coils discharges between balls or plates took place more readily and through greater distances than between points—a fact which is exactly contrary to what is found in the case of air.

It has recently been found that while alcohol is a partial conductor for ordinary currents it is an insulator for very high frequencies, and it appears probable that water itself, and perhaps ordinary electrolytes, such as a solution of salt, would behave as nonconductors with a sufficiently high frequency applied to them. By taking advantage of the inductive effects of a condenser of considerable capacity discharged across a spark gap or a pair of gaps in series, upon which a blast of air is kept blowing, and having also in the circuit of the discharge say 15 turns of coarse wire wound into an open coil used as a primary, with a secondary coil of a single layer of some hundreds of turns of finer wire wound on an insulated frame or support, and with the primary immersed in an oil vat, remarkably high potentials are readily obtained. The coils are separated by oil, the thickness of layer depending on its resistance to puncture by the discharge.

In the largest apparatus yet constructed the primary coil has 15 turns wound double of No. 6 wire, and the turns have a diameter of 22 inches, while the whole coil is spread to an open helix of 28 inches in length; weight 14 pounds. The secondary coil is wound on a hard rubber open frame, and consists of 580 turns of No. 26 wire, the turns having 17 inches diameter, and the coil being 28 inches long. It contains about 2,600 feet of wire; weight 2¼ pounds. These coils are immersed in an oil vat of wood and are held concentrically. The terminals of the fine wire are carried out at the ends of the oil vat in the center of a trough about 5 inches square filled with oil, and the conductor is so kept covered with oil to the very end, where it is at last exposed.

In experiments with this coil, with the terminals 64 inches apart, it gave torrents of sparks between them. The sparks were blue white, and from the terminals branching forked discharges took place in all directions to distances of two or three feet. These sparks are by far the longest ever produced artificially, and the apparatus is so simple and of such slight cost that it is extremely doubtful whether any such large Ruhmkorff coils as the Spottiswoode coil, with its 280 miles of secondary wire, will ever be made again. With the simple oil-insulated apparatus described a torrent of sparks (250 per second) was obtained. Heavy glass plates or slabs of other insulating materials are readily punctured, and where the discharge does not puncture but spatters over and around the slab the effect is very beautiful and impressive. Hard wood plank is perforated and set on fire, sticks are splintered and the known effects of lightning are reproduced in a very complete way.

The development of ozone in the neighborhood of the apparatus is very great, and soon renders the air pungent and irritating. It appears from the experience gained up to this time with the apparatus that it would be possible to produce apparatus on similar lines capable of developing electric potentials sufficient to leap the space between electrodes twenty or more feet apart.

Especially striking, also, are the experiments which concern the passage of these high frequency discharges through a person's body. Even with frequencies not higher than two thousand per second the late Dr. Edward Tatum found that a dog could support a greater current than if the current were continuous in character. With still higher frequencies it is probable that greater immunity would exist.

By holding a metal or carbon rod in the hand while standing on the floor or seated near the high potential apparatus, and providing small wires and bits of wood suspended from one terminal of such apparatus, while the other is connected on the other side to a length of wire or a metal plate, sparks may be taken between the wire or suspended objects and the rod held in the hand, and these may be a number of inches in length in an apparently continuous stream. In this way the small wires may be melted down and objects set on fire, pieces of wood charred, etc., by the curents passing in the spark and through the person's body. Notwithstanding the striking effects, the current is scarcely felt at all.

By the use of vacuum tubes and plates or wires extending from or connected to the terminals of his high frequency coil, Mr. Tesla has produced very brilliant effects of illumination of such tubes. In fact a vacuum tube may be used to explore the high frequency electrostatic field around the high frequency apparatus very much as a compass needle may be used to explore a magnetic field. It has long been known that a Geissler tube lying near a powerful Ruhmkorff coil in work would frequently become luminous, but the high frequency apparatus produces all effects obtainable with a powerful Ruhmkorff coil in far greater intensity.

It may be asked why in the construction of the high potential induction apparatus I have selected a primary of only 10 or 15 turns. In answer it may be said that it was found that while a greater number of turns would naturally give a greater magnetic effect, and therefore greater magnetic change and more powerful induction, yet the use of such greater number would so lower the frequency in view of the desirability of using condensers of rather large capacity relatively as to lose more than was gained. The induced electromotive force depends on the rate of change or frequency, as well as on the total field undergoing change. Again, should we attempt to run up the frequency by still further diminishing the turns, what we so gain is lost in diminished ampere turns or magnetic field, especially as there will always be a certain impeding inductance in the connections or leads from the condenser plate to the primary coil. This inductance should be cut down as much as possible by the use of wide strips for such connections and by a non-inductive arrangement of them where it is possible.

It may be remarked in conclusion that, as concerns the secondary of the apparatus as well as that of a Ruhmkorff coil, the effects are not purely electrodynamic, but are modified by capacity. In every coil in which high potentials are generated, especially at high frequencies, the electrostatic induction of the turns of the secondary upon each other and upon surrounding or adjacent conductors, particularly the primary coil parallel to the secondary, are not to be neglected. From the center turns of the secondary outward to the terminals a progressive elevation of potential exists before the passage of a discharge. This brings into play the capacity of the secondary turns, as parts of a condenser receiving charge, and with high potentials this capacity is quite considerable. From the fact, as developed by my experiments, that such high potential apparatus needs to be carefully proportioned or otherwise the effects will be disappointingly small, I am satisfied that such relations should exist between the inductance and the capacity of the secondary conductor as to keep it in phase with the primary oscillations, and any condition which produces an undue positive or negative lag in the secondary phase will weaken materially the effects. It remains simply

to state that of course the medium surrounding the apparatus is traversed by rather long Hertzian waves, which could readily be detected by proper resonators, and that further the apparatus can be used to charge the Hertz apparatus instead of an induction coil. I should anticipate that the production of the Hertz effects in a more continuous and vigorous way than hitherto would follow the adoption of these modern means for securing high potentials.

BRANCHER'S ELASTIC CLUTCH.

THERE are few apparatus that have excited the spirit of research of inventors as much as the clutches used for coupling two shafts placed in prolongation of one another. Many combinations of this kind are known. The clutch devised by Mr. Megy may be enumerated among those that have been most favorably received in practice. It is well to recall the arrangement of it. Upon the driving shaft is keyed a collar surrounded at some distance by a coupling box fixed to the shaft that it is a question of revolving.

Circular springs of tempered steel covered with leather upon their convex surface are placed between the collar and box. These springs revolve with the collar. The curve given them is such that, left to themselves, they apply themselves exactly to the interior of the box and exert therein a pressure sufficient to carry along the latter with the shaft to which it is attached, or to surmount the strongest resistances to which the shaft can be exposed. To stop the motion, it suffices to contract the circle formed by the springs to a sufficient degree to prevent them from adhering to the box. This effect is obtained by means of a combination of pulleys and an endless chain. The pressure of the springs against the box may thus be varied and the stress to be transmitted be limited as may be desired.

A friction clutch that somewhat resembles Megy's has been devised by Mr. A. Brancher, but this engineer, instead of having recourse to the elasticity of springs, utilizes the enormous friction given by a flexible band wound several times around a drum. As well known, the ratio between the force of traction of one of the extremities of the flexible band and the stress to be exerted upon the other extremity varies according to an exponental function of the arc of winding. This remarkable property, applied in the capstan, was put to profit a few years ago by Captain Lemoine in the construction of a brake for carriages. In the Brancher clutch the elastic band is composed of steel faced with leather, and which makes two and a half revolutions around a drum. Fig. 1 represents this band developed in a plane. It will be seen that the successive revolutions enter one another in order to apply themselves to the circumference of the drum. Each couple represents a complete revolution less 25 per cent. for the play of expansion and closing of the steel band collar.

The stress to be exerted by the driving shaft upon the small end of the band is very feeble. The force transmitted by the large end to the shaft actuated is considerable. Such stress, in fact, is multiplied according to the formula $M = R, e^{f\theta}$ (320 to16, 000), according to the number of bands.

A small conical friction clutch, movable according to the driving shaft and loose upon it, is set in rotation through a very slight stress by means of a drum or pulley keyed to the same shaft. This cone draws the small end of the elastic band, the other extremity of which winds around the pin of a disk keyed to the shaft actuated.

As soon as the friction cones are slightly engaged, the impulsion takes place. The stress exerted upon the shaft actuated can be regulated by a maneuver with a lever.

Figs. 2 and 3 show the arrangements of the details of construction.

The friction cone, C, loose upon the shaft, A, is capable of being shifted upon it by means of a forked lever that permits of bringing the cone into contact with the drum, G, keyed to the extremity of the same shaft. On another hand, the disk, P, provided with a crank pin, M, is keyed upon the actuated shaft, A'. The elastic collar, R, formed of steel ribbons, is wound around the drum, G. The narrowest band, which occupies the median position, is firmly fastened at its extremity to a rod fixed to the cone, C, and jointed to two other bands which are themselves connected with a third play of bands connected in the same manner with a fourth of greater width whose extremities embrace the pin, M.

Under such conditions, the tightening of the collar brings about a connection between the disk, P, and the drum, G, when the latter carries along the cone, C, through adhesion.

It must be remarked that this clutch is capable of transmitting the rotary motion in one direction only. For applications to motors with reversal of direction, Mr. Brancher has studied the arrangement represented in Fig. 4, which includes the use of two concentric drums and two elastic bands. It is adapted also for high powers.

Upon the driving shaft, A, is keyed a friction cone, N, sliding under the maneuver of a lever and carrying along the disk, P, loose upon the same shaft. This disk carries a rod, Q, to which is fixed the smallest spiral, *r*, of the collar surrounding the external rim of the double drum, *g*, which likewise is keyed upon the shaft, A. As for the two larger spirals, r_1 r_1, of the same collar, they are fixed to the bolt, R, of the disk, M, keyed to the shaft, A'.

When the cone, N, is not in contact with the disk, P, the collars, r r_1 r_1, are distended and do not touch the drum, G, but, as soon as it carries along this disk through friction, the slight tension thus given to the spiral, *r*, is progressively multiplied upon the drum, so that it is shown by a considerable stress upon the pin, R, of the disk, M. The drum, G, is thus strongly squeezed by the collar, and shafts A' and A become interdependent; but with a graduation such that the impulsion passes without jerks from the initial velocity, o, to velocities of 100, 200, and 500 revolutions for any stresses whatever upon the pin, R.

In case of a reversal of direction, the operation is produced in the same way.

Then it is the collar placed upon the inner rim of the double drum that comes into play. It unwinds, in fact, in a direction opposite the preceding. This result is obtained by rigidly connecting with the disk, P, a disk, Q, carrying a rod connected with the thin band of the internal collar at a point diametrically opposite the junction of the internal collar with this same disk.

This clutch is applicable to the transmission of motion by gear wheels, and Fig. 5 represents the adaptation of it to the powerful pinion of the large wheel, M. Two collars, the winding of which is done spirally upon a single drum, have their thin and strong extremities respectively at E and P. The object of this doubling is to transmit high powers in a single direction of rotation.

In order to well graduate the maneuver of the clutch, the friction cone is provided with a screw mechanism. Upon the transmission shaft is keyed a coupling box, G, serving as a support to a lever, L, which is dis-

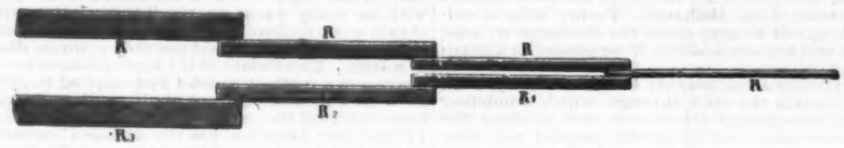
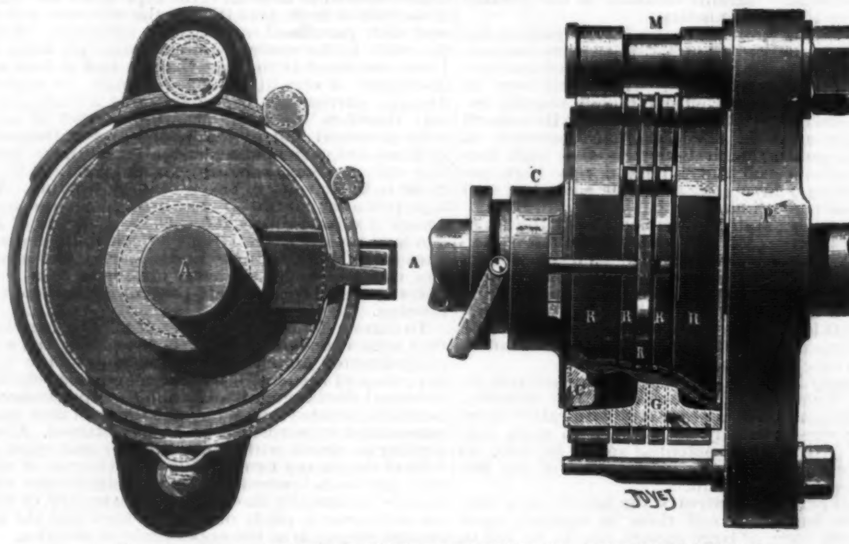


FIG. 1.—DEVELOPMENT OF THE ELASTIC BAND.



FIGS. 2 AND 3.—CLUTCH FOR ROTATION IN ONE DIRECTION.

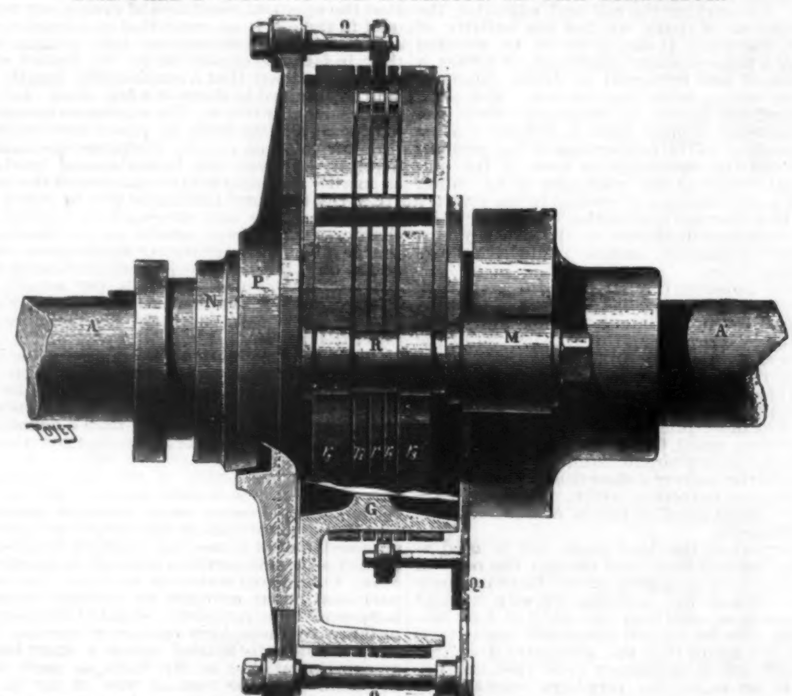


FIG. 4.—CLUTCH FOR ROTATION IN TWO DIRECTIONS.

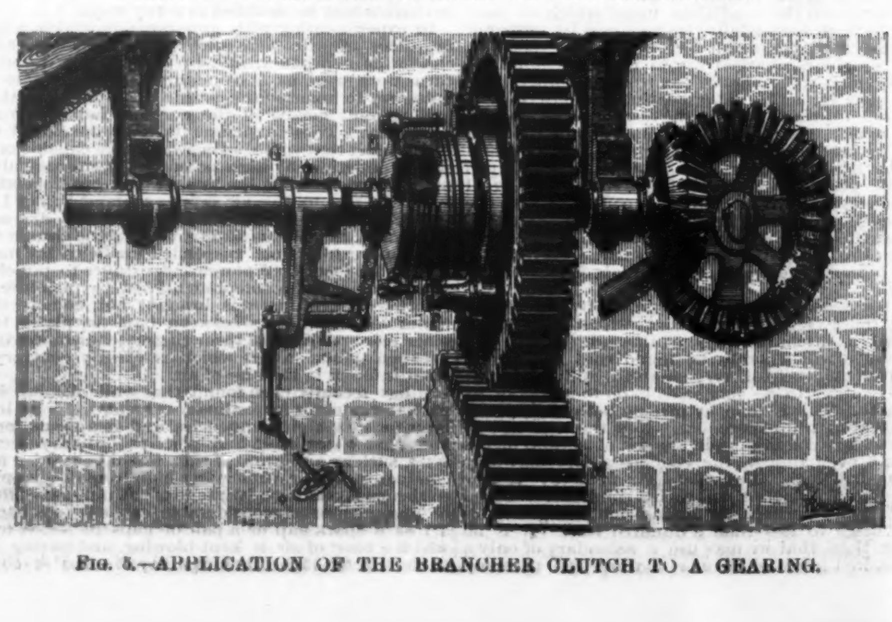


FIG. 5.—APPLICATION OF THE BRANCHER CLUTCH TO A GEARING.

placed by the screw, *l*, when the hand wheel, *o*, is actuated.

Another variant has been studied by Mr. Brancher for transmissions actuated by two motors at the same time, say by a turbine and a steam engine. The cone of the apparatus is then provided with pulleys playing in eccentric grooves, thus permitting of an impulsion by the motor revolving the most swiftly without influencing the operation of the other motor. All chance of accident is thus avoided.

Upon the whole, this clutch is most ingenious. It has already given its proofs in important applications, and its services well justify the favorable reception that has been accorded it.—*Revue Industrielle.*

MOVING OF A LARGE MASONRY BUILDING IN CHICAGO.

THE Normandy Apartment building, formerly standing at Nos. 116, 118, 120 and 122 Laflin Street, Chicago, Ill., which has been moved to Van Buren Street, for the Metropolitan Elevated Railroad Company, is supposed to be the largest building ever moved and turned around on rollers. (See Fig. 4.)

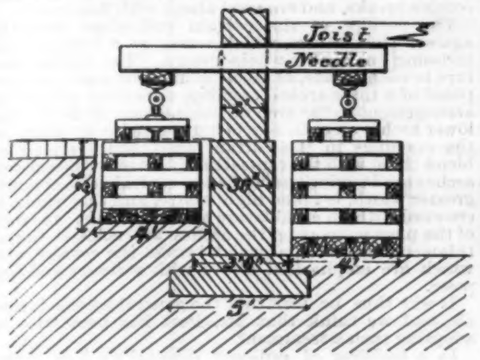


Fig. 1

BEFORE RAISING.

The building was moved east 200 ft., then turned around to a north front and moved north to the new foundation about 150 ft. more, making a total distance of 350 ft. without counting the turn. The dimensions of the building are 94 by 84 ft., built of brick, with a gray granite front and terra cotta trimmings.

Weight about 8,000 tons. Twenty-four men were employed about ten weeks to complete the work of removing the building from the old to the new foundation. Eight hundred jack screws were required to raise the building, and 600 rollers were used in the moving.

The details of the mode of moving and supporting the building are as follows: A trench 4 ft. wide and 2 ft. deep was excavated all around the outside wall, so as to give room to place the necessary blocking, as in Fig. 1. Cribs were built on both sides of each wall, and jack screws placed in position on these cribs of timber benches, as close together as they could be crowded. Cap timbers were then placed on top of these screws lengthways of the building, care being taken that the inside and outside cap timbers were on the same level.

Holes were then cut through the wall on a level

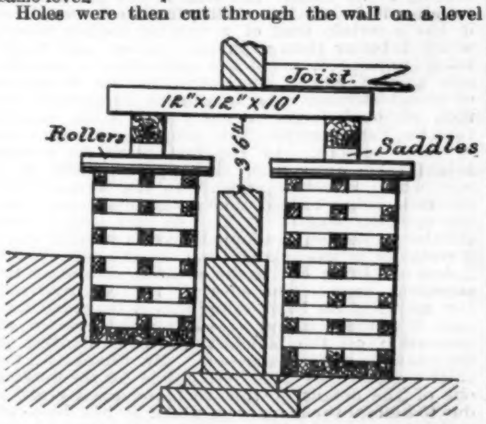


Fig. 2.

AFTER RAISING.

with the top of the cap timbers on needles; 12 by 12 by 10 ft. timbers were run through the wall, each end resting on a cap timber with the wall in the center; the holes were cut on an average of 2 ft. from center to center of each needle.

All around the building, at intervals of every twelve feet, long timbers were run clear through the building, so as to make a cross binder or tie for all the cap timbers.

After the needles and timbers were all in place they were all keyed up with wedges of the proper taper to fit the opening on top of the needles between the wall.

The screws were then divided between the men so that each man had on an average ten screws to turn; the signal to turn was given with a whistle, by the foreman, whose business it was to see that each man should take one turn each time the whistle sounded.

The screws were tightened up in this way till the wall began to separate from the foundation, when all the men releveled the cribs to get them in perfect level before starting to raise again. The building in this way was raised 3 ft. 6 in., which was the height required for placing our rollers. (See Fig. 2.) 6 by 6 blocking was placed across the cribs, and 4 by 5 hickory skids were laid lengthways of the building, and the rollers placed on top of these. The rollers were hard maple, 8 in. in diameter and 4 ft. 8 in. long.

Saddles were then placed between the top of the

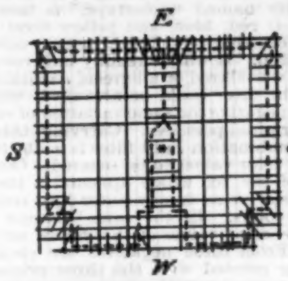


Fig. 3.

Timbers running east and west are cap timbers. Timbers north and south, cross timbers. Short lines are needles. * Pivot; axis of building.

rollers and the bottom of the saddles (4 in. by 12 in. by 6 ft. oak), and the intervening space then wedged up tight and the screws then slacked out and removed.

The building was then ready for moving. We give photographic cuts showing the appearance of the building, front and rear, after the rollers had been inserted. Jack screws 7 ft. long were used to push the building back to the turntable 200 ft. east. The turntable

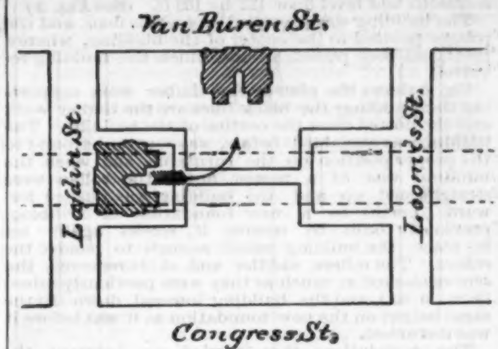
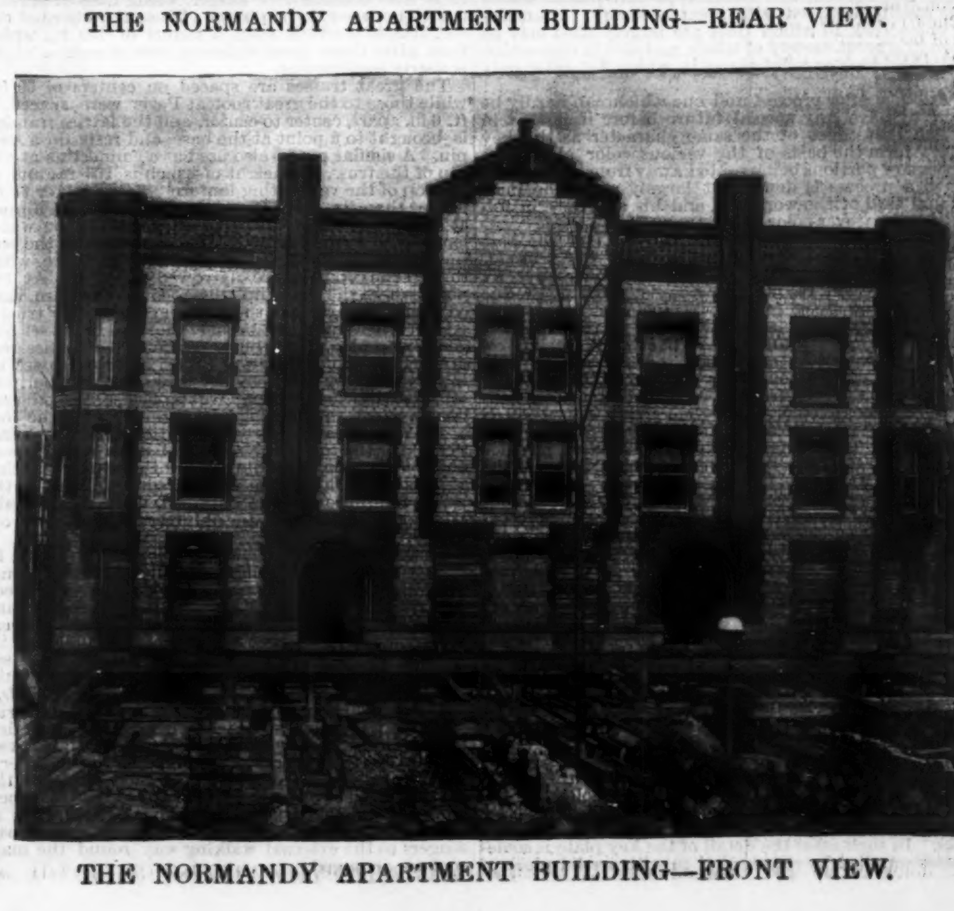


Fig. 4.

was a level mass of timber work, 132 by 132 ft. square and 4 ft. deep, built of 200,000 ft. of 6 by 6 timbers laid on ground that had been thoroughly scraped and brought to a level. The ground was sprinkled with sand and then paved with plank laid closely together.

THE NORMANDY APARTMENT BUILDING—REAR VIEW.



THE NORMANDY APARTMENT BUILDING—FRONT VIEW.

The framework of timber was then built on this foundation and again thoroughly leveled, a surveyor's instrument being used in the work. The framework of 6 by 6 timbers was then covered with 4 by 5 hickory skids 12 ft. long by 3⅞ in. thick, which made a smooth and level floor 132 by 132 ft. (See Fig. 2.)

The building was propelled on to this floor, and the rollers pointed to the center of the building, where a pivot had been placed, around which the building revolved.

Fig. 3 shows the plan of the timber work supporting the building; the black lines are the timber work and the dotted lines the outline of the building. The building, as explained before, was revolved around to the proper position on the turntable, and when the building was at a proper angle, the rollers were straightened up and the building was pushed forward (north) to a new foundation of cribbing, previously built to receive it, screws again set in place, the building raised enough to remove the rollers. The rollers, saddles and skids removed, the screws slacked as much as they were previously raised (3 ft. 6 in.), and the building lowered down to the same height on the new foundation as it was before it was disturbed.

The foundations then carried up between the timbers and thoroughly wedged, the timbers then taken out, and the building soon ready for occupancy.

This notable work was executed by L. P. Friestedt, of Chicago, who is well known as an experienced and successful architectural engineer.

AMERICAN COLOR PROCESSES.

Attendant upon the widespread use of photographic engraving, a corresponding increase in color work has taken place. In contrast with the older processes of color work, the present movement is in no way confined to establishments in which color printing predominates. So varied are the processes now in operation that, instead of looking simply to lithographic firms for colors, every office with its individual platen press or its cylinders may become a factor in this work. As might naturally be expected in view of the numerous methods of engraving and also of printing, in conjunction with the more ordinary work, a wide variety of standards may be observed. While giving full recognition to lithographic processes this article is especially devoted to those methods of color work which come within the range of the printing office.

So far as the printer is concerned, the methods in use are largely the same, color printing being a matter of a number of impressions in different colors of ink. Nearly all of the work for artistic purposes is based on using either four or five colors—black for the key plate, red, blue and yellow, and sometimes an additional red or blue of a different shade. Attention will be given first, however, to the methods employed in making the plates themselves. Beginning with the simplest method of color printing from flat tint blocks, a variety of gradations are found following after and tending toward the color process best known throughout the world—by the famous French typogravures. If the full outlines of the work are planned in advance, flat tint blocks are easily made by photographic prints upon various pieces of metal, each one being started in the same manner as for the key plate. The portions which it is desired to retain are then "painted in" by hand, following the lines of the print upon the zinc and carefully protecting the necessary surface. The remaining portions are then etched away, leaving only the individual tint desired. In this manner various tint blocks may be made, insuring absolute register with the key plate.

Other processes of making tint blocks are those of transfers from the key plate and routing away all portions not needed, and electrotype tint plates, which are readily prepared with great accuracy. Examples of color work in which tints are largely used may be seen in a great variety of labels, and also in connection with half tone or relief plates in which flat color only is required.

Another color process, and one which can hardly be said to have any special future before it, is that in which half tones of the same character as the key plate form the basis of the various color plates, the necessary portions being routed away from each block. Such a process is dependent largely upon the individual skill of the workman, and his accuracy in following whatever color scheme may be supplied.

A half tone key plate forms the basis of the best color work, not only in this country but abroad. There are two methods of making color plates by which excellent results are secured. One method is based on the use of grained blocks made from transfers from the key plate, and etched in the ordinary manner, a certain amount of painting-in being required, however, in the various steps of etching. It is also necessary to rout away various portions of the plates. The results from these plates admit of a delicate blending of colors, and when a very fine grain is secured the mechanical outlines of the work are very obscure. Slight variations in register do not produce the undesirable effects which sometimes result in the case in which several line plates are used. The second process of particular merit, and upon which the famous French work is based, consists of transfers upon drawing paper from the key plate and individual drawings for each color. Photo-engravings are made from these drawings. The printing surface secured by this process consists largely of fine hand stipple, and in certain portions of the strongest colors some cross lines are used.

There is a singular sentiment, often to be found, that it is not artistic or workmanlike to introduce tool work or variations to accomplish certain results. While it is unfortunately the case that unskilled tool work often appears in such a way as to detract from the engraving rather than to be an improvement, yet with proper treatment the final results are greatly improved. Such is the case in which some portions of the key plate are eliminated, in order to give as great strength as possible to certain colors of the background, such as may be in the brilliant costume of any army officer or strong coloring in draperies. In such cases the detail of the key plate is sometimes supplied by blocking it in with a solid piece of metal, then tooling all away with the exception of such few lines as will indicate the detail without reducing the color.

Another form of color work which is in limited operation in this country, and which gives great promise, is that based entirely upon photographic processes directly from the colored object itself. This process, which has been termed "photography in colors," and more recently named "colortype," is based on the principle that red, blue, and yellow form the three primary colors from which any desired color or tone may be secured. It will be readily understood that if the original was all red or all green, a suitable complementary light filter could be arranged, which would yield on the negative the same variation of color values which the original possesses. Carrying this idea still further, a combination light filter is made for each of the primary color values to be secured. One negative yields all of the red which appears in the original, either by itself or as it may enter into combinations with other colors. In the same manner negatives yielding the color values of the yellow and blue are obtained. From these negatives are etched plates, which, being printed with the three primary colors, give the reproduction with absolute accuracy of color and detail from the original. The prints from this process have very much the same effect as from strictly half tone plates, and are often mistaken for such. The plates are, however, known as "single line plates," each color crossing the others at an angle, slight variations in register not producing the blurry effect which sometimes results in the case where the colors are laid in parallel lines.

American color work, as a whole, is remarkable for the mechanical finish of the print itself; and, with the wider adoption of the various processes and the cultivation of the general taste in artistic effects and harmony of color, color printing will meet with its full appreciation in every line of commercial and artistic illustration.—*Engraver and Printer.*

[Continued from Supplement, No. 926, page 14798.]

THE WORLD'S COLUMBIAN EXHIBITION: A GENERAL VIEW.

The Manufactures and Liberal Arts building, erected from the designs of Mr. Geo. B. Post, of New York, is by far the largest in the Exhibition, and from a construcive point of view the most important. It is the largest covered structure in the world, and occupies a space of 30½ acres.

The southern facade, which has a length of 787 ft., occupies a space immediately opposite the Agricultural building, on the other side of the grand basin, while the main or longer axis runs north and south for a length of 1,687 ft., and extends into the northern portion of the grounds toward the United States Government building; it is bounded on the west by the wooded lake. Mr. Post, in making his ground plan, surrounded his area with a continuous building, consisting of a nave and two aisles, in all about 200 ft. wide. The original intention was then to place in the center of the inner area thus left a huge dome, which was to be 260 ft. in clear diameter and 160 ft. high, surrounded with two-storied aisles, like the structure going round the outer portion of the site, and which were to be 45 ft. in width.

This scheme had, however, to be abolished in order to find room for the large number of exhibits for which space had to be found, especially as France and Germany threatened to withdraw unless it was conceded. Having these conditions to face, Mr. Post was obliged to abandon the idea of the dome, and he resolved to cover the whole of this internal court with one large unencumbered space, with a span from center to center of supports of 368 ft., the largest span of any roof ever erected, and about 6 ft. wider than that of the great Machinery Hall at the Paris Exhibition of 1889. It is also considerably longer, being 1,268 ft. in clear length between the supports. The outer chord of the roof trusses is struck from a radius of 190 ft., which thus gives these great trusses a form of section which is nearly semicircular.

The great trusses are spaced on centers of 50 ft., while those to the great roof at Paris were spaced 70 ft. 6 in. apart, center to center, and the lattice framing is brought to a point at the base and rests on a steel pin. A similar pin is also used as a connection at the top of the truss, the height of which is 206 ft., and to the top of the ventilating lantern 245 ft. 6 in., or 61 ft. higher than the Paris example. The roof is hipped at each end, and is covered with a lantern the whole length and round the hips. The trusses near the bottom are 14 ft. in width and 2 ft. 4 in. on face, while toward the top they are narrowed to 10 ft. At the point where the huge hip trusses come, they are varied to suit the sweep of the roof, the four corner trusses which, when taken up, become the hip, being set diagonally on plan. The outer flange of the trusses goes up vertically for a height of 100 ft., and the trusses up to this point are connected by three pairs of horizontal trussed girders, and above by lattice-framed purlins on which the light open rafters rest. At the foot of the raised lantern, already mentioned, which is carried along the top of the roof, is placed a walking way about 6 ft. wide, extending round the whole building at this point, and from which a splendid view of the whole Exhibition can be obtained, while across Lake Michigan on the east an uninterrupted view is obtained.

On the ground floor a covered loggia, about 20 ft. deep, surrounds the building on all sides, and the upper gallery to the inside aisles projects inward between the great trusses at a height of 20 ft. from the ground level. For the purpose of the erection of these great trusses a traveling stage was used. The galleries inclosing the great roof consist of a nave with raised roof, as has been mentioned, open to the top, while the aisles on each side are covered with lean-to roofs.

At regularly spaced intervals on the plan, galleries supported by columns are taken across at the first floor level to connect the gallery floors of the two aisles. For the purpose of ready access to the gallery, groups of staircases are placed at each angle of the building, and two on each side of the central entrance, while twelve others are conveniently placed, while at the north end of the building lifts which convey passengers to the external walking way round the main roof are arranged.

To design a building one-third of a mile long and nearly one-sixth of a mile wide, and with a height limited to 60 ft., the height agreed upon by the architects whose buildings abutted on the central court, was the task then given to Mr. Post, who took as his module or unit of measurement a length of 25 ft., or half the space between the main trusses. This disposition allowed him to place 58 of these openings in each long facade, *i. e.*, 29 on each side of the central feature and 22 openings on each of the shorter facades, *i. e.*, 11 on each side of the central feature, for which he allowed a space of 122 ft. 6 in. in width, the great trusses being specially placed opposite these to suit this feature. The general idea of the elevation consists of a series of square piers with Corinthian-like caps from which spring semicircular arches, the spandrels being filled in with carving of a not very high order; above is placed a boldly designed cornice 60 ft. high, crowned with a balustrade, the piers below being emphasized by flag poles. At the four corners of the building, where the four outer aisles cross one another, are placed pavilions about 60 ft. square, slightly projecting beyond the general face, and consisting of a semicircular arch on each side, bounded with two pairs of Corinthian columns, right and left round which the cornice breaks, and crowned above with flag posts.

The cornice of the curtain wall stops abruptly against this feature, which serves as a boundary or inclosing line for the whole design. The central feature in each facade, of about double the width, is composed of a three-arched opening, somewhat similar in arrangement to the arch of Constantine at Rome, the lower arches on each side being the same as those of the openings in the curtain walls, thus helping to blend these with the central *motif*. Above the smaller arches are inscriptions, while the central arch, of much greater width, is taken high above, and the whole is crowned with an entablature and a low attic. In front of the piers supporting the arches are colossal Corinthian columns, around which breaks the cornice, and which are emphasized above with statuary and flag poles.

It will thus be seen that the general scheme is simple, and we think that Mr. Post has been wise in adopting such a treatment.

In a building of ordinary dimensions, it is sometimes customary, in order to avoid excessive appearance of length, to introduce features with an upward tendency, to correct this lengthy feeling, as has been done at the Agricultural building opposite; but it will readily be seen that in a building one-third of a mile long, it becomes impossible to take in at a glance the detail of any such features, which would consequently appear meaningless, and tend to take away from the dignity of the composition as a whole. These fifty-eight openings of a similar design on the main front tend to give the facade an appearance similar to that of the old Roman aqueducts seen stretching across the country around Rome, and which gain most of the dignity they possess in the repetition of their parts. The sky line has been left unbroken in Mr. Post's design, save for the flag posts occurring over each pier, and the raised angle and central features, which are bodily accentuated.

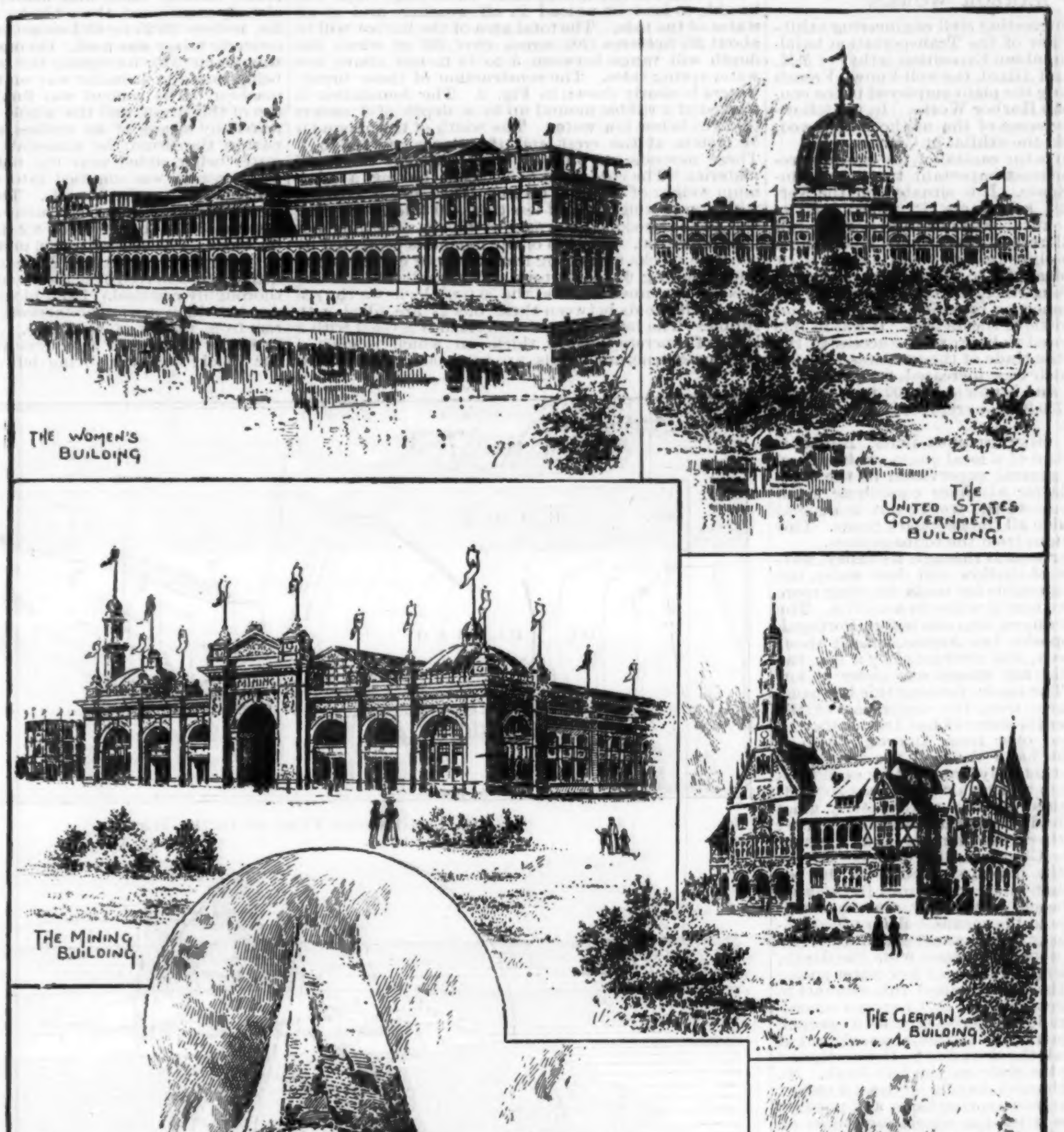
The effect of the great roof rising in stages across the outer roof, and crowned by the walking way and the lantern at top, is very fine, and composes well.

As to the interior, the great roof itself is an object lesson of the greatest interest, apart from its wide span. The framework of steel strikes one as being considerably lighter than the Paris example, the trusses being formed of triangular bracing between the inner and outer flanges, instead of cross-bracing as at Paris. The steel is not painted, but remains as it left the works; the result being that it has a certain tone of a varying reddish brown, which is better than a painted surface, and which, being unpainted, saved the authorities a considerable sum of money, amounting to some thousands of pounds sterling. As to general appearance, the roof, although larger in every way, looks smaller than the Paris example; this can be ascribed to two or three reasons. In the first place, its greater height takes away from the apparent width in a way which is very marked. In the second place, the ends being hipped take away immensely from the apparent length. It may be said that a semicircular proportion as adopted here is a better one—it certainly is more classic; but, on the other hand, it does not bring out to the greatest advantage the enormous span. The effect of the comparatively low arches of the Paris example, and the gable ends, gave it a breadth and a length which created an impression on the beholder which is wanting in the example under discussion. Mr. Shankland, the chief engineer, has been responsible for the working out of the details of this roof, and great credit is due to him for the manner in which it has been carried out, as also to the contractors, the trusses being erected with a rapidity which is without parallel for a work of this importance.

The sculpture decoration has been designed and carried out by Mr. Karl Bilter, of New York, under the architect's direction. Of course, it does not compare with the work on the Administration building or the Agricultural building in importance. At the base of each flag staff to the main entrance is an eagle with outstretched wings. If the sculpture is unimportant, it is made up for by the colored decoration in the spandrels and domes of the central and angle pavilions, on which some of the best artists in the States have been employed; these will be dealt with in a special article on the color decoration of the building, which will appear later.

The Electricity building designed by Messrs. Van Brunt & Howe, of Kansas City, is placed on a site which has a frontage of 350 ft. to the great court, and whose major axis has a length of 700 ft. running north and south. The building is bounded on the east by the North Canal, connecting the Grand Basin with the picturesque lagoon, and on the west by the avenue which separates the Mines building from the Electricity building, and the center of which is on the axis of the Administration building. The plan of the building is divided up into 23 ft. bays, corresponding with the interior supports to the galleries.

The general scheme consists of a nave 115 ft. wide, and of about the same height, crossed at right angles in the center by another nave of the same proportions. The trusses are composed of a light iron framework of steel, the upper part being semicircular in the outline, the trusses being composed of inner and outer members, and connected by lattice bracing; at the base the standards are brought to a point and rest on a steel pin. The back members of the standard are taken up above the aisle roof, and have clearstory windows formed in this portion, while the lower portion of the roof itself is filled with glazing. The remaining portion of the area on the ground floor is spaced out to correspond high, the arch mouldings springing from the main cornice. Above, and supported as it were by Corinthian pilastars, is a pediment filled with sculpture and supported by figures emblematic of electric lighting and the telegraph, while the whole is capped by an attic crowned with a horizontal cornice, the whole central feature being supported on either side by consoles. In the center of the semicircular entrance is placed a statue of Franklin, 15 ft. high, and resting on a pedestal with the historic kite and key, observing the storm clouds. The upper part of the entrance under the arch is treated as a half dome, divided by ribs carried above the Corinthian pilasters, which are continuous are placed the restaurants. The eastern and western entrances are treated as porticoes, slightly projecting, and with circular ends brought back to the face of the curtain walls. As to the elevation, the main scheme consists of a series of fluted Corinthian pilasters 42 ft. high, crowned with entablature and balustrade which break around the pilasters and are carried up with flag posts. Between these pilasters at the first floor level is a horizontal cornice supported in the center by an Ionic column. The main entrances are raised and crowned with sculptured pediments on the east and west sides. Against these the roofs of the main naves abut. On either side of these entrances, with



SKETCHES AT THE WORLD'S COLUMBIAN EXPOSITION.

with the 23 ft. bays of the elevation, with wooden posts supporting the gallery floor, through which light is admitted from skylights in the flat roof which covers these galleries, at every alternate bay. Access to these galleries is obtained by means of four large staircases and by subsidiary ones.

In the center of each of the four sides is an entrance pavilion, against which the roofs abut, and which are treated somewhat differently. The southern end of the building, abutting on the main court, is provided with a covered ambulatory extending the whole width of the facade, in the center of which is the principal entrance, consisting of a semicircular recessed porch 78 feet in width. It is treated as a triumphal arch, 60 ft. wide and 92 ft. with those running round the building. This covered portion is treated in a light key with color. From this semicircle three doorways lead into the central nave, while one on each side leads into the covered ambulatory. The northern entrance, facing on the lagoon, is recessed behind a one storied loggia, whose roof is supported by Ionic columns of the same type as those which support the galleries on the facades. This loggia is also treated in bright colors of yellows or reds, while above, on the main wall, is a huge semicircular window expressing the great nave. On either side the surrounding and storied aisles are projected forward beyond the loggia and finished with circular ends struck from a radius of about 50 ft. On the upper story the exception of that abutting on the court, towers 28 ft. wide, are taken up for a height of 170 ft. to the east and west entrances, and 190 ft. to the north entrance. Besides these, and giving a vertical tendency to the composition, in the center of each curtain wall on either side of the central *motifs* in each facade is carried up a tower, 150 ft. high, with circular dome, which is gilded,* and at each angle of the building a tower in three stages is also raised above the pavilions which mark these points. These towers are introduced by the architects, so as to accentuate the vertical elements and to give to the

* These pavilions project slightly and contain doorways at the ground level which act as subsidiary entrances.

general design a movement which, "in contrast with its neighbors, may be suggestive of the mysterious functions of electricity." The ironwork of the main roofs is painted a light blue color, which gives it a lightness which is very suitable, but the ironwork itself is very light in structure, and differs in this respect from the Mining building next to it. The scale of the Electricity building is smaller than the buildings which surround it, and the whole composition is more varied in outline than any of the buildings which abut on the main court, and which we believe it was the purpose of the architects to accentuate.

(*To be continued.*)

BILBAO HARBOR WORKS.

AMONG the most interesting civil engineering exhibits in the French section of the Transportation building of the World's Columbian Exposition is that of MM. Coiseau, Couvreux, and Allard, the well-known French contractors, illustrating the plant employed in the construction of the Bilbao Harbor Works. In the following article we describe some of the methods followed, and specially shown in the exhibit at Chicago.

The town of Bilbao is the capital of the Basque provinces, and one of the most important trading and industrial centers of Spain. It is situated on the Nervion River, about 12½ kilometers (7·7 miles) from its mouth, which opens out into the deep and narrow gulf of Gascogne. Up till recent years there has been no harbor at Bilbao, the ships trading there having to be of sufficiently small draught to allow them to ascend the shallow and winding river, the banks of which are covered with the numerous factories, foundries, and steel works characteristic of the district. It was in 1878 that it was first proposed to improve the access to the town. At that date the trade of the port was 1,340,000 tons per annum, which was increased to upward of 2,000,000 tons in 1879, and is now 4,500,000 tons per annum. Of this total, 750,000 tons represent imports and 3,750,000 tons exports.

As in the case of other Spanish ports, Bilbao is under the direct control of a local junta, which, however, is subject to a general supervision by the state authorities. These latter at times contribute small amounts to the expenses of the works, but in general the junta has to provide all the necessary funds. This it does by appropriations from the tonnage dues.

Up till 1878 the river wound through its valley, having alternate reaches of shallow and deep water, the shoals rendering it impossible for boats drawing more than ten feet to twelve feet of water to ascend it. The mouth, protected by quays, viz., one before Portugalate and the other opposite Las Arenas, spaced about 160 meters (525 ft.) apart, was obstructed by a bar, the depth over which did not exceed one meter at low water spring tides. The sands forming this bar came to a very slight degree from the upper part of the river, but mainly from the shore of Las Arenas, though a little also is carried over from Algorta, which is situated on the right hand shore of the bay. The sea currents were continuously transporting sand from the Las Arenas shore in a direction from east to west, though the waves raised by the northwesterly gales and by the ebb tide had a contrary tendency. After a careful study of these peculiarities and a study of old charts, M. De Churruca, the engineer to the junta, decided that the deposits of sand on the bar were not large, and that they arose from the erosion of the right hand beach of the bay, and that this could be checked by suitable means. Before the commencement of the works, the channel cut by the river through the bar was about 200 meters wide, the depth, as already stated, being 1 meter at low water spring tides. The drift of the sand caused this channel to move in a westerly direction. M. De Churruca accordingly determined that it was necessary to fix permanently the western boundary of this channel, and at the same time to check the drift due to the northwest gales by prolonging the mole on the left bank. He thus hoped to get a channel having at least 3 meters depth of water at low water spring tides, and possibly as much as 3½ meters when the regulating works on the upper reaches of the river were completed. It was decided to carry out these recommendations, and the Portugalate mole was accordingly constructed. This mole is 800 meters (2,625 ft.) long, and extends up to a depth of 6½ meters (21 ft.) beyond the extreme edge of the outer slope of the bar. It is built on a curve of 3,000 meters (9,850 ft.) radius, the concavity being turned toward the channel. The base of this mole is a rubble mound formed of blocks weighing one ton as a minimum. Through this, for 570 meters of the total length, screw piles are sunk, on which is fixed an iron platform, the upper surface of which is 7¾ meters above low water. Between these piles, from the top of the mound to a height of 4·2 meters above low water, the mole is made up of a concrete monolith, intended to guide the flow and ebb currents in the desired direction. For a further distance of 30 meters the concrete is carried up to the lower surface of the iron platform.

For the remaining 200 meters this method of construction could not be adopted, the sea being too strong. The mound in this case is protected by thirty-ton concrete blocks. Its upper surface is leveled off with a layer of concrete ½ meter (19·9 in.) thick, on which rests the superstructure of the mole. This is from 8 to 10 meters wide at the bottom. It is faced with blocks of Portland cement, having 5·6 cubic meters capacity. The filling is of concrete moulded in place. On the sea face the superstructure is carried up as a shelter wall 3 meters high by 3 meters thick, and above this again comes a parapet 1 meter high.

These works were finished in 1890, and the river was also regulated and trained, cuts being made through certain bends, and a good waterway dredged through the various shoals. The result of these operations has exceeded expectations, and ships drawing 20 ft. to 23 ft. are able to enter at high tide, where formerly boats drawing only 12 ft. to 13 ft. dared not risk the entry. The cost of the works was about 16,000,000 francs.

In spite of the fine results thus obtained, the entrance to the river was always difficult during the presence of northwesterly gales, and ships were often obliged to take refuge in other ports. It was accordingly decided to construct a deep water harbor in the bay, capable of receiving the largest ships. As shown in Fig. 1, the bay is well adapted for a work of this kind. The depth of water is great and regular, the 10 meter line passing near the shores and near the mouth of the river. The anchorage is also excellent, the bottom being sand. The works are now in progress, and consist of two breakwaters, one 1,450 meters (4,760 ft.) long, which reaches out from the left shore of the bay at a point about 2,600 meters (1·6 miles) from Portugalate. The other reaches out from the right bank at Begona Point, and will be 1,072 meters (3,516 ft.) long. Between the ends of these two breakwaters is the entrance to the harbor, which is 640 meters (2,100 ft.) wide and is perpendicular to the direction of the prevalent winds. On the shore inside these breakwaters quays are to be constructed, which will be well provided with railway lines, and at which large ships will be able to load or unload in all weathers and at all states of the tide. The total area of the harbor will be about 287 hectares (700 acres), over 200 of which the depth will range between 5 to 15 meters above low water spring tides. The construction of these breakwaters is clearly shown in Fig. 2. The foundation is formed of a rubble mound up to a depth of 6 meters (19·7 ft.) below low water. The width of this mound is 54 meters at the crest and the slopes are 1¼ to 1. These mounds are built of three different classes of material. The core consists of blocks having a minimum weight of 20 kilos. (44 lb.) This core is covered with stones weighing not less than 400 kilos. (881 lb.), and the outer slope is formed of blocks weighing not less than 1 ton. The top of the mound is protected by concrete blocks measuring from 30 to 50 cubic meters and weighing 60 to 100 tons. The smaller blocks are used on the inner side and the 50 ton blocks on the sea side. The voids between these blocks are filled with rubble. The foundation thus formed is leveled with a layer of concrete 1 meter thick, on which is erected the superstructure. This, up to 1 meter above low water to 7 meters above it, is formed of concrete blocks weighing 10 tons each and laid to break joints. The interior is filled with quick-setting cement concrete. The dimensions of this part of the superstructure are 12·2 meters at the bottom and 10 meters at the crest. From this level there is a shelter wall 3 meters high and 4 meters thick, crowned by a parapet 1¼ meters thick and 1 meter high. Both shelter wall and parapet are made of cement concrete moulded in place. The base of the superstructure is protected by a concrete toe, 4 meters broad and 2¾ meters thick.

The concrete used in the 60 and 100 ton blocks has the following composition: One part Portland cement, 3 of shore sand and 6 of broken stone. The 10 ton facing blocks are of rather a richer mixture and consist of 1 part Portland cement, 3 sand and 5 broken stone. The leveling course and the concrete toe are constructed with quick-setting Zumaya cement concrete and have the following composition: three parts of cement, 4 sand and 9 broken stone. The breakwaters will terminate in a circular pier head 20 meters in diameter at high water level, on which will be fixed lighthouses. The contract for the western breakwater was given to MM. L. Coiseau, A. Couvreux fils, and Felix Allard, contractors, Paris, the price being 20,500,000 francs.

The stone for the rubble mounds and for the concrete was obtained from the Axpe quarries, near which there is a convenient dock. The explosive employed for loosening the stone was dynamite, small charges only being used, as the bed is not very homogeneous, there being frequent pockets of clay. A meter gauge line was laid down along the front of the quarry, and served to convey the material to the loading staithes and concrete yard. Four 12 ton locomotives were constantly employed. The large stones were loaded into the wagons by 3 ton locomotive cranes, while the one-man stones and the spawls were loaded into tip wagons by hand. These latter were taken to the concrete yard, where they were broken up for making the concrete. On the loading staithes, three cranes, supplied with steam from the workshop boiler, were used for loading the barges, which are of the type shown in Figs. 4 and 5. The doors closing the bottom of the hopper of these barges are worked by hydraulic power. The principal workshop for the repair and maintenance of the plant employed was erected on the river embankment behind the Axpe dock, and the concrete yard was also located here.

In 1888 it was decided to adopt electricity for working all the plant required for making and handling the concrete blocks, and to this end a special traveling crane, transfer table and loader were designed. As already mentioned, these blocks measured 30 to 50 cubic meters (39·25 to 65·4 cubic yards) each. A Carey concrete mixer was used. On one side of this machine was an elevator for raising the broken stone, the sand being raised in a similar way on the other side of the machine. The cement was finally poured in at the top of the drum, and the whole contents thoroughly mixed by means of an endless screw. In the upper part of the drum the materials were mixed dry, the water being added near the bottom. The concrete, when ready, was emptied into small wagons, which conveyed it to the moulds. The moulds for the 30 meter blocks measured 4 meters by 3 meters by 2·5 meters (13·1 ft. by 9·8 ft. by 8·2 ft.), and for the 50 meter blocks 4·63 meters by 3·6 meters by 3 meters (15·1 ft. by 11·8 ft. by 9·8 ft.) A steam crane was used for lifting the concrete over the moulds, into which it was thoroughly rammed. Each block was finished on the day on which it was commenced, in order to avoid any risk from planes of weakness. At the end of four or five days the moulds were removed, to be used again, the block, however, being left to harden for three months, when it was ready to be raised and carried to the barge which conveyed it to its final resting place. To facilitate the handling of the blocks, two steel eyes were fixed in each block as it was being moulded. Storage room was provided for 500 of these blocks. Heavy rails were placed between the rows of blocks for the traveling crane to run on. Considerable care was taken to get a good foundation for these rails, but there were nevertheless cases of settlement. This settlement required a very great increase in the power used in traversing the crane.

As already mentioned, the plant for handling the blocks was worked by electricity. The dynamo supplying the current was driven by the 60 horse power compound workshop engine, and supplied a continuous current at 220 volts, when running at 300 revolutions per minute. Bare conductors were used exclusively in distributing the current, and were fixed on insulators carried by posts or walls, as was convenient.

The traveling crane was built of iron, and its only peculiarities arise from the use of the electric current for working it. It consists of two stout standards resting on wheels, balancing levers being used to distribute the weight. These wheels are 0·85 meter (2·6 ft.) in diameter. The standards are spaced 5·7 meters (18·7 ft.) apart, and are connected at top by two stiff girders carefully braced together. These girders carry hydraulic jacks, by means of which the actual lifting is done. In the cabin on top of the girders is placed the electric plant which works the pumps supplying the hydraulic jacks and the traversing gear. The collectors, as will be seen, are of the usual overhead tramway type, and are connected with a Gramme motor, designed to run at 630 revolutions per minute, which is reduced to 30 at the pump shaft and to 20 at the traversing shaft, by

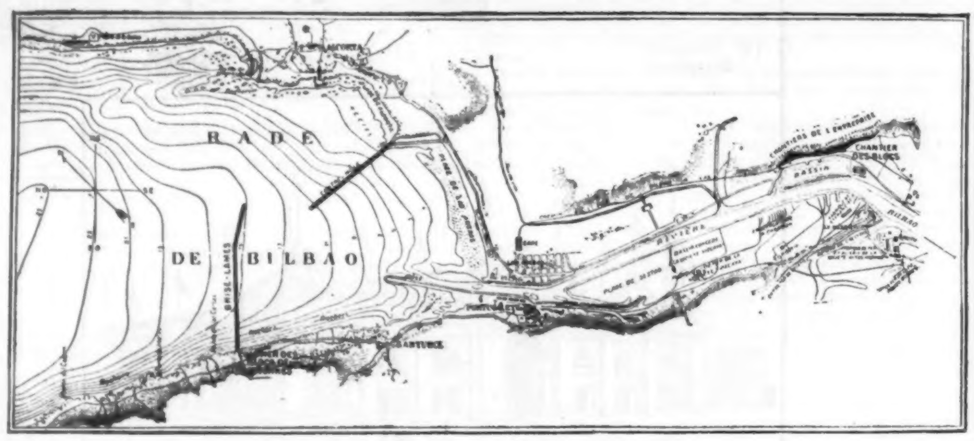


FIG. 1.—GENERAL PLAN OF OUTER HARBOR.

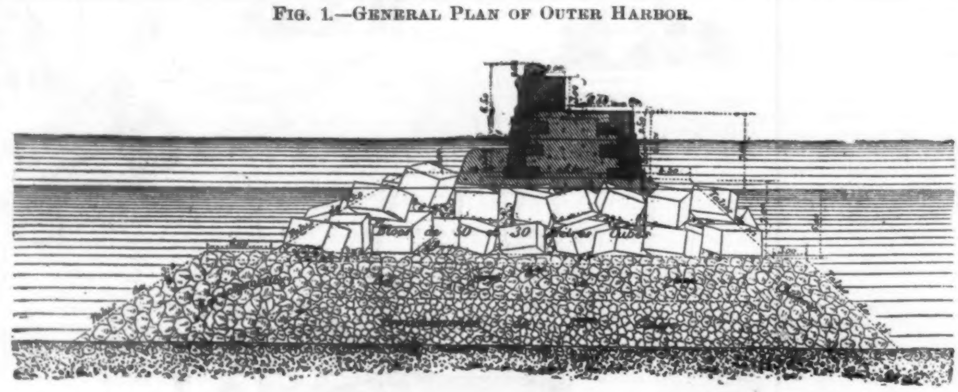


FIG. 2.—SECTION OF BREAKWATER.

THE WORLD'S COLUMBIAN EXPOSITION—FRENCH EXHIBITS OF BILBAO HARBOR WORKS.

means of worm gearing. Reversal is effected by making use of a second set of brushes on the commutator. The method of working is as follows: The crane is brought over a block, the hooks are lowered by letting water out of the hydraulic presses, and the crane is then slightly moved forward, so that these hooks engage with the eyes moulded into the blocks as already explained. By setting the pumps at work, the block is then raised some 0·2 to 0·3 meter (9 in. or 12 in.)

The crane is now traversed on to an electric transfer table, with the crane in place on it. The block is then lowered on to this table, on which it is conveyed to the loading staithe.

This transfer table is 6 meters long by 4·6 meters (15 ft.) broad, and consists of eight cross girders 0·350 meter (1·14 ft.) deep, resting on four axles, placed in pairs at the ends of the table, and connected together at their ends by girders 0·75 meter (2·46 ft.) deep, on the

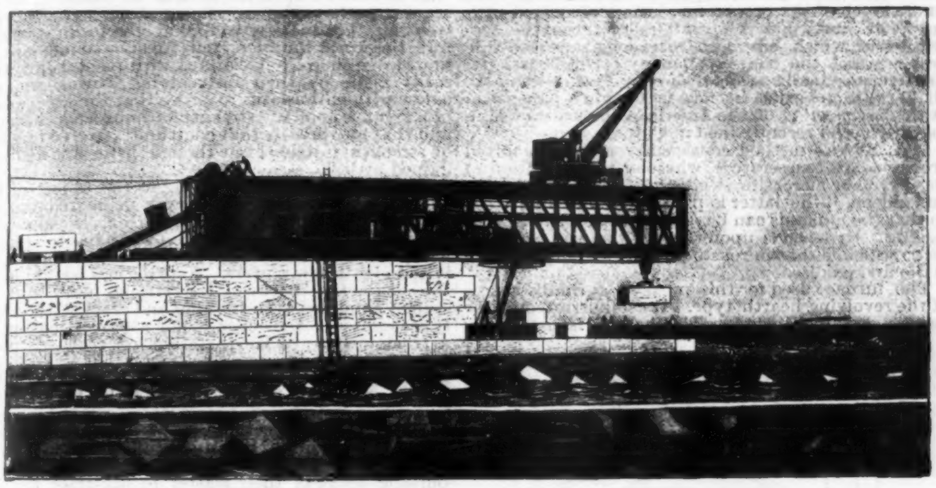


FIG 3.—SIDE VIEW OF ELECTRIC TITAN.

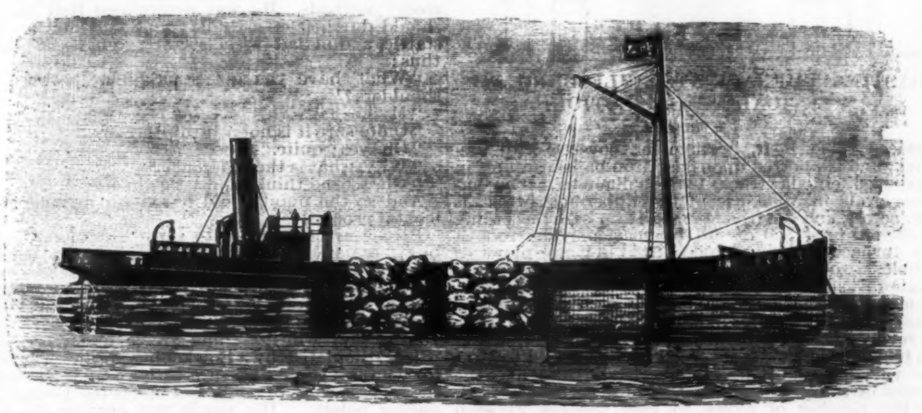


FIG. 4.—HOPPER BARGE FOR TRANSPORT OF ROCK FOUNDATION.

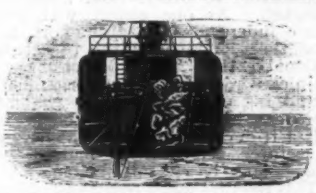


FIG. 5.—SECTION OF HOPPER BARGE.

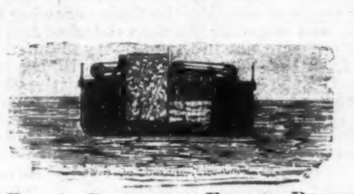


FIG. 6.—SECTION OF HOPPER BARGE.

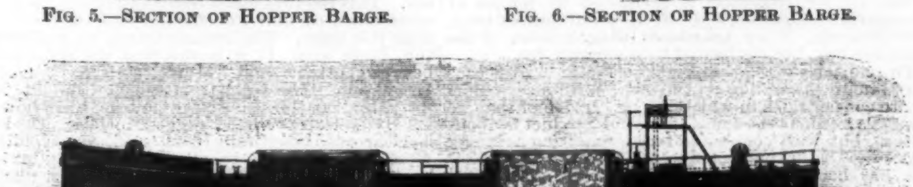


FIG. 7.—HOPPER BARGE FOR TRANSPORT OF BLOCKS.

THE WORLD'S COLUMBIAN EXPOSITION—EXHIBITS OF FRENCH ENGINEERING WORKS.

top of which are fixed the rails for the reception of the crane. Each axle of the truck carries two wheels 0·6 meter (1·9 ft.) in diameter, and, as will be seen, there are four lines of rail, which weigh 54 kilogrammes per meter (108·8 lb. per yard). The motor used for maneuvering this truck is the same type as that belonging to the crane. It runs at 600 revolutions per minute, which is reduced to 5·7 turns per minute at the driving wheels.

On the loading staithe is a second traveling crane, very similar to that used in the concrete yard, but differing from it in that its wheels are fixed direct to the standards without the intermediary of balancing levers. The hydraulic jacks have also a greater travel, viz., 7 meters (23 ft.), and they project above the cabin roof on top of the crane. The gauge of the crane is 5·7 meters (18·7 ft.), and the rails are fixed on the top of a strong trestle, between the legs of which there is sufficient space to admit the transfer table. The supports of this trestle are piles, 25 meters (82 ft.) long, of which 12 to 13 meters (39 ft. to 42 ft.) are below ground, this great penetration being necessitated by the nature of the material passed through. The piles were not driven to refusal, but nevertheless there has been no settlement. The total time required to transfer a 100 ton block from the store yard and load it on board its barge is less than one-quarter of an hour.

The plant has proved remarkably economical. Though probably only 55 per cent. of the power supplied to the dynamo is obtained as useful work, still the power is supplied by an economical engine, which would not be the case if each separate crane had been, as is usual, supplied with its own engine and boiler. A single mechanic only is required to look after the three machines, as common laborers are quite capable of working them. The maintenance has been practically nothing, the chief expense being new brushes every three months. The commutators also require turning up about twice a year.

The type of barge used for conveying the blocks to the site of the breakwater is shown in Figs. 6 and 7. The doors at the bottom of the hopper in which the blocks are placed are worked by hydraulic jacks. As will be seen, these doors do not extend completely across the opening at the bottom. They are connected to the jacks by chains. During transport these chains are locked by keys so as to take the load off the presses, but on arriving at the desired spot the jacks are pumped up slightly so as to take the pressure off the keys, which can then be withdrawn, and on now letting the water out of the presses the doors are lowered and allow the block to fall out. The whole operation only takes a few seconds. About 52,000 cubic meters were thus laid in 1892.

The electric plant originally provided proved so satisfactory that an electric Titan was also designed for building the superstructure. It is shown in Fig 3. It consists of two main girders of steel, 31·7 meters (103·9 ft.) long, 4·5 meters (14·7 ft.) high, and spaced 3·75 meters (12·3 ft.) center to center. These two girders are strongly braced together by cross girders, which divide the total height into three stages which form platforms on which various operations can be be effected. On the lower stage is a concrete mixer, which is mounted so that it can be traversed in either direction for a distance of 20 meters (65·6 ft.) It is worked by a 12,000 watt compound-wound motor. A second motor of similar construction and capacity works the elevators which bring up the material, a centrifugal pump for supplying water and also traverses the traveling crane which is placed on the uppermost platform of all. By means of chain gearing this same motor effects the traversing of the whole Titan. The wagons conveying materials for the concrete are raised to the second staging by a chain elevator. As the facing blocks weigh only 10 tons each, the movements of raising, lowering and turning of the traveling crane are effected by hand. The whole Titan rests on 16 wheels resting on two lines of way spaced 3·05 meters (10 ft.) center to center, the gauge of each line being 0·70 meter (2·3 ft.). The distribution of these wheels is shown in Fig. 3. The overhang of the front of the crane is 20·1 meters (66 ft.) A counterweight of cast iron is provided at the rear end of the Titan.

The current for the motors is supplied from a 24,000 watt dynamo, which supplies a current at 220 volts. It is driven by a 35 horse power semi-portable engine. The conductors are bare copper, and are carried on porcelain insulators fixed on poles. The efficiency of the plant is 65 per cent.

In working with this Titan, a level bed is first prepared on top of the rubble mound by adding a layer of concrete 1 meter thick. This concrete is mixed on board the Titan, the cement being quick setting.

From the mixer the concrete is passed down through a shoot. When this leveling bed has been finished for a distance of 5 to 6 meters in advance of the finished work, the facing walls are built with the 10 ton blocks, the concrete filling being built up simultaneously. All the joints between the blocks are carefully made water-tight by grouting. Rapid work was essential on the tidal portions, so that the concrete mixer was built with a capacity of 30 cubic meters (39 cubic yards) per hour. When a length of 20 meters (66 ft.) is finished, rails are laid in advance of the Titan, which is then pushed forward to a new position. The whole of the plant has worked well and regularly; the principal precaution necessary being to keep the motors from damp, which may cause short circuits. The cost of the plant was not greater than plant of similar capacity of the old type would have been, and the working was much superior.—*Engineering.*

[FOR THE SCIENTIFIC AMERICAN.]

THE SEPARATION OF ZINC BLENDE FROM IRON MINERALS.

By WALTER RENTON INGALLS.

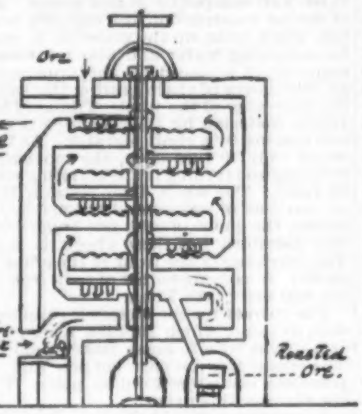
ZINC blende, which is perhaps now the most important ore of zinc, occurs in nature very generally associated with siderite (carbonate of iron) and pyrite (sulphide of iron), more often the latter than the former. The separation of these minerals before treating the blende for zinc is important, as iron is a very undesirable element in the retorts, which are corroded rapidly by it, thereby leading to a loss not only of retorts, but also of zinc by the volatilization of the contents of those which break in the furnace. The smelters of zinc ores in the Mississippi Valley will not, therefore, buy ores which carry more than 7 per cent. iron. European works do not draw the line so low, but an ore with more than 10 per cent. iron is considered to be of inferior grade and is paid for accordingly. With the market standard thus determined it is necessary to sort over the mine's product with much care and at considerable expense, in order to keep the percentage of iron below it.

Hand sorting is only available, however, with lump ore, in which the minerals can be easily broken apart; with ore in which the blende and pyrite are closely interwoven, and with fines which cannot be picked over, it is necessary to adopt another mode of treatment. This was long a serious problem, as the specific gravities of blende (3·9 to 4·1), pyrite (4·8 to 5·2) and siderite (3·7 to 3·9) are so nearly alike that separation by jigging in the ordinary manner is obviously impossible; but recently two new systems have been devised and put into use with very successful results. Both are mechanical processes, but one is magnetic while the other is gravimetric, the former having been introduced in Europe and the latter in the United States.

The mines belonging to the "Silber- und Bleibergwerk 'Friedrichssegen,'" near Ems, in the valley of the Lahn, Germany, produce an ore which consists of a mixture of argentiferous galena, argentiferous chalcopyrite (copper pyrites), and blende, with spathic iron (siderite), and a quartzose gangue. This ore is first sorted over, on coming from the mine, and the lumps of pure mineral of one kind and another are picked out. The remainder, which is of course the most part, is then sent to the dressing works, where it is crushed and jigged, whereby the heavy and valuable minerals are separated from the worthless gangue and in part from each other. The final products are galena, which is easily concentrated by virtue of its high specific gravity, and a mixture of blende and siderite, which it is impossible to separate by wet dressing for the reason already explained. The first-class concentrates are shipped to lead smelters, and the second to the magnetic separation works further down the valley.

In the magnetic separation works the blende-siderite concentrates (which assay about 15 per cent. zinc and 27 per cent. iron) are first roasted for the purpose of driving off the carbonic oxide of the siderite and converting it into magnetic oxide. The calcination is effected in a furnace of novel design, which is illustrated by the accompanying sketch. There are five circular hearths, one above the other, over which revolve plows carried on radial arms from a vertical axis which turns in the center of the furnace. The hearths have circular V-shape grooves, in which the plows run, thus insuring a thorough turning of the ore. The fire box

is at the bottom of the furnace, the flames drawing over each hearth in succession, finally passing into a dust chamber, in the same manner as in an ordinary reverberatory furnace, with three, or more, rectangular hearths. The ore is fed on the uppermost hearth from the top of the furnace, and then passes down over each hearth in succession in a direction opposite to the draught. The plows on each hearth are set at such an angle as to give the ore the longest possible travel, pushing it slowly ahead until it drops to the next hearth below. There are doors in the side of the furnace, which allow the progress of the work to be observed and give access to the interior when repairs are necessary.

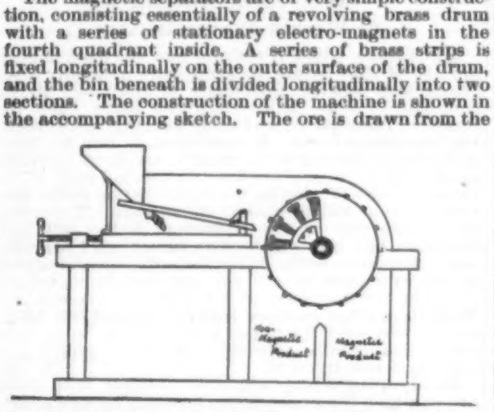


ROASTING FURNACE AT FRIEDRICHSSEGEN. VERTICAL SECTION.

The calcination is effected at a red heat, but the charge passes through the furnace so quickly that the blende loses only a small part of its sulphur, though the siderite is converted almost entirely into magnetic oxide of iron. Each furnace calcines from 22 to 27½ tons of ore every 24 hours, with a consumption of about 5 per cent. of coal, while two men per shift of 12 hours attend to two furnaces. The cost of calcination is small, therefore, amounting to about 33½ cents per ton, but, of course, wages are not high in Germany.

The calcined ore drops from the furnace into an iron car beneath it, and is wheeled to the cooling floor, where it is spread out and lies until its temperature falls to about 120° F. It is then shoveled into a chain elevator, which raises it to the top of the separating mill, where it is sized by drum screens into a class of two-millimeter grains and a class of four millimeters. The screens discharge into wrought-iron bins, whence the ore is drawn to the separators as required.

The magnetic separators are of very simple construction, consisting essentially of a revolving brass drum with a series of stationary electro-magnets in the fourth quadrant inside. A series of brass strips is fixed longitudinally on the outer surface of the drum, and the bin beneath is divided longitudinally into two sections. The construction of the machine is shown in the accompanying sketch. The ore is drawn from the reservoirs in the top of the mill to the machine hopper, from which it is distributed on the drum in a thin, even sheet by an automatic shaking feeder. The non-magnetic particles, *i. e.*, the blende chiefly, are not attracted by the drum and fall into one of the bins below it; while the magnetic ore is carried in the opposite direction by the revolution of the drum until they pass out of the influence of the magnets, when they drop into the other bin. The separation is thus effected, but in practice one operation is not sufficient to make clean products, and it is necessary to repeat it.



MAGNETIC SEPARATORS AT FRIEDRICHSSEGEN.

The separating machines are arranged in groups of four, the machines of each group being placed on two different levels. The calcined ore passes first over the two upper machines, which give a product rich in zinc and a product rich in iron. The product rich in zinc passes over one of the two lower machines, and the product rich in iron passes over the other, whereby are made a finished zinc product, a finished iron product and an intermediary product (from both machines), which falls into the boot of a belt elevator, is raised to the reservoir at the top of the mill and undergoes the same treatment a second time. The final zinc product contains from 37 to 42 per cent. zinc and 6 per cent. iron at the most. It is sold to the zinc smelters, for whom it is not an undesirable ore. The final iron product, which contains about 40 per cent. iron and less than 4 per cent. zinc, is sold to the blast furnacemen. It may be mentioned, in passing, that the zinc contained in such iron ore is reduced in the furnace, volatilizes, oxidizes in the upper zone, and collects on the sides as crusts of zinc oxide, which are broken off, and in Germany sent to the zinc smelters for the recovery of their metal.

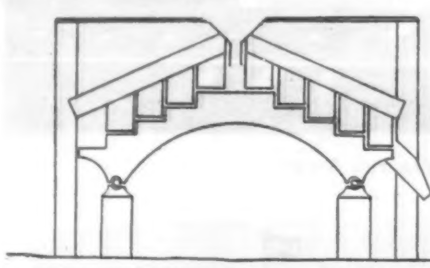
The magnetic separation works at Friedrichssegen have three groups of four machines, or twelve machines in all. Each group consumes one horse power for magnetization, and 0·6 to 0·7 horse power for movement, the drums turning 45 times per minute. Each machine separates about one-half a ton of ore per hour. All are covered with tightly fitting hoods to prevent the escape of dust into the mill.

The magnetic separation of blende and siderite has been tried at several other places in Europe, notably at Pezibram, in Bohemia, and at a works in Spain; at the Monteponi mines, in Sardinia; also limonite and ocher have been separated from calamine (carbonate of zinc) in a similar manner; but there the ore is roasted with admixture of a small percentage of coal in order to reduce the hydrous ferric oxide to magnetic oxide. The installation at Friedrichssegen, however, is the largest and most successful, I believe, that has yet been made. The plant, which was originally experimental, has been enlarged from time to time, and has now been in regular operation for a number of years, so that its methods are now recognized as a useful and practicable process of ore dressing.

Another system for cleaning zinc blende from iron minerals has been more recently adopted by the Wisconsin Lead and Zinc Company, at Shullsburg, Wis., where much of the ore occurs, intimately mixed with marcasite and pyrite, both sulphides of iron, the separation of which has been for a long time a vexing problem and the subject of many experiments. Its solution was finally accomplished by Prof. William P. Blake, who described his new method in a paper read at the last meeting of the American Institute of Mining Engineers, recently held in Chicago.

Prof. Blake's method consists in roasting the mixed ore at a low temperature, whereby the condition of the pyrite or marcasite is changed, while the blende and galena, if the latter is present, remain unaltered; so that the minerals can be separated by a subsequent jigging. It depends upon the well-known metallurgical principle that in roasting mixed sulphides, pyrite is the first oxidized.

The furnace used for this purpose at Shullsburg is of the revolving hearth type. It is illustrated in the accompanying drawings. The hearth is a circular, terraced table, 16 ft. in diameter, covered with firebrick, and supported upon cast iron balls running in a grooved, circular track, 12 ft. in diameter. The terraces are 18 in. wide, except the uppermost, which is 4 ft. across, and are from 6 in. to 12 in. high, according to the nature of the ore to be roasted. The roof of the furnace is dome-shaped; fixed in it are plows or rabbles, two over each terrace, which are set at an angle of 45 degrees, and turn the ore over in a succession of furrows as the table revolves, moving it constantly from the center outward. The hearth is made to revolve slowly, generally not over 10 revolutions in an hour, but of course its speed may be varied to meet the varying conditions of an ore. So also may the height of the plows above the terraces be changed, or the number of plows, to turn the ore at each revolution or at each half revolution, as may be desired.



ROASTING FURNACE AT SHULLSBURG, WIS. VERTICAL CROSS SECTION.

The fire box is at one side, the flames drawing across the hearth and entering the dust chamber and chimney at the opposite side in the ordinary manner. The ore is fed from the top of the furnace, in the center, automatically, the rate depending upon the distance of the lower end of the feed pipe from the top of the table and the speed of the table itself. The ore is discharged from the lowest terrace through a spout into iron cars or a chain belt conveyor. Very little labor is required, therefore, for the operation of the furnace.

The air for oxidation is preheated by means of Siemens accumulators, built in the usual form of brick checker work. They are placed on both sides of the main fire box, but are heated by a separate fire.

The capacity of the furnace varies from 10 to 20 tons per 24 hours, according to the ore. With fine blende-pyrite concentrates in which the proportion of the two minerals is about the same, the usual product is about 20 tons, but with coarser material, requiring a longer exposure, the output is reduced. The most desirable size has been found in Wisconsin to be grains about one-fourth of an inch in diameter.

In practice the product is delivered from the furnace without being in the least sintered, and as granular as when fed. Beyond a comminution of the blende by decrepitation there is no change in the character of the concentrates, except in the case of the pyrite. The blende is not decomposed, scarcely losing its bright luster, while the galena is barely tarnished, but the pyrite becomes spongy and bulky on losing its sulphur, and by virtue of this change the subsequent separation by jigging is effected.

The process as now carried out at Shullsburg is as follows: The crude ore from the mine is crushed, sized and jigged, giving a concentrate containing about 25 per cent. of blende, 25 per cent. pyrite and 5 per cent. to 10 per cent. galena. This is sent to the furnace, described above, and roasted at a dull red heat for about twenty minutes. The roasted ore is then re-jigged, giving a blende concentrate with as high as 60 per cent. zinc, less than 3 per cent. iron and 1 per cent. lead, which is a very good grade of zinc ore.

Experiments have been made in America and in Europe upon the magnetic separation of blende and pyrites in somewhat the same manner as blende and spathic iron are separated at Friedrichssegen, but this process has not yet been made a commercial success.

The chief difficulty is in converting all the pyrites into the magnetic condition. When fully oxidized the iron passes into the form of sesquioxide, which is not attracted by magnets, and it is difficult to stop the roasting at the exact degree of partial oxidation required. It has been suggested that the sesquioxide may be reduced to magnetic oxide by the introduction of carbonaceous material in the furnace, as has been done at Monteponi in Sardinia, but Prof. Blake's gravimetric process of separation, as carried out in Wisconsin, has been so successful, according to his reports, that the field for a magnetic process in that region at least would be circumscribed.

EDWARD THRING.

By G. Wolcott Brooks, Dorchester.

Edward Thring was an educational pioneer. He was one of the first to note the contrast between culture and cramming. In his great work as headmaster of Uppingham School, England, he demonstrated that the mind is an intellectual power to be trained, not a truck to be loaded.

As he entered upon his work as an educator, he was eager to perform the experiment of managing boys by wooing rather than by whipping, and to illustrate before the world the idea that juvenile minds are not knowledge shops, to be stuffed with mental furniture, ready made by their instructors. Thring was also aglow with enthusiasm to prove that the chief object of a great school is "strength of mind and character, and that any process that contributes to give this kind of strength is true, even though little knowledge is gained by it."

Thus he emphasized training as the object of true education. Mere knowledge was made tributary to that end. "Education," says Thring, "means training for life; life, not lessons, is what has to be dealt with, or lessons only so far as they inspirit life, enrich it and give it new powers. Nothing can be said before the distinction between the strong mind and the stuffed mind, between training and cram, is thoroughly recognized. A teacher is not a parrot master, not a truck loader at a goods station. A teacher's object is not to load up his pupil with facts, but to train him how to get facts for himself. The teacher's aim is to create producing power." One of the highest functions of an instructor is to impart himself to his pupils, to enkindle in their minds his enthusiasm, and to make contagious his own scholarly habits. In the Uppingham school, every student was enthused with the burning desire of their master to illustrate the idea that education is not cramming for an examination, but training for life.

In the execution of his high design, Thring employed model methods. He was determined that the boys should do their own thinking. Sometimes he would startle a dull lad with Socratic queries beginning thus:

"What have you got sticking up between your shoulders?"

"My head."

"Quite sure it is not a turnip?"

"Oh, yes; quite."

"Why, what is the difference?"

"Oh, a head thinks and a turnip does not."

And so the pupil would be led into an independent mental process.

People are ever ready to shirk thinking; they will buy manuals, read *Review of Reviews*, attend lectures, consult editorials, reject weighty books and in every other possible manner dodge the necessity of mental effort and pay others to do the thinking for them. This same indolence of mind characterizes youth; they will not think except under pressure or when stimulated by a quickening spirit. The educator who is a genius has a creative soul. He touches the inner springs of being and starts the thought-producing powers. His pupils will acquire the art of accurate observation, and will possess the power of communicating to others their impressions in clear-cut English. As one object with Thring was to stimulate independent mental effort, he strenuously opposed the prominence given to lectures in modern educational methods. The object of the lecturer is to communicate knowledge; he has stuffed himself with facts and his aim is to stuff his students. The true teacher deals not so much with books as with minds. "He is a trainer, not a truck loader," says Thring. "The lecturer is like a ready-made clothes shop. His knowledge must be cut into the most acceptable manner. This requires much command of the book to be communicated and an effective delivery, but when done it is done. The lecturer leaves his audience and they leave him. It is in this that the difference lies between teacher and lecturer, between taught and belectured. The teacher makes the taught do the work, and occupies himself in showing them how to do it. His work is to direct, suggest, inspirit. The lecture is clear cut, beautifully connected, yet avoiding all close and laborious exactness. Teaching takes any shape, is fragmentary, disregards all precise plan, provided that a close, laborious, and exact exercise of mind is the result. The lecturer does the work and goes. The teacher makes his pupils work, and stands or falls by what they do. One thing is certain, the teacher and the lecturer represent two opposite poles; there is an antagonism in principle between a subject put forth attractively, when the master does the work and the disciple listens, and the problem of a dull mind solved and dormant faculties roused to efficient powers, when the disciple does the work and the disciple's mind is the subject, and the teacher is a practitioner on mind."

Entertaining such views, Thring rejected the current dictum that knowledge is power, and he believed that true force resided in the culture of the mind. That which he sought to produce was power in one's self. Often the minds of pupils are so crammed as to render impossible any independent intellectual effort.

Dickens' character old Squeeres had at least one good educational idea; he insisted upon the boys putting in practice all the information received. The tyrant master would write h-o-r-s-e on the board and then a shivering lad would be dispatched to the stall to groom the old nag and acquire a practical knowledge of the subject. And b-o-t-a-n-y was written on the board and some Smike or Nicholas was hustled off to the garden to weed the beets and cabbages and thus get in touch with nature. A gigantic evil in the modern school consists in this—the teacher does the work and the pupil is simply receptive.

Thring made a great specialty of developing a mag-

nificent manhood. His students had resources in themselves. It was one of the moulding principles of his life to get inside his boys, for he regarded this as the only means by which mind could be reached and true success attained. He says, "The kettle lid, on or off, and the pumper give a very true picture of modern theory and practice. Pumping in knowledge is not education. The teacher and the trainer has to make his pupil strong, and skillful in himself. Pumping and being pumped on is not teaching and being taught. The shut mind defies all such attempts to reach it. Nothing can be done so long as the lid remains on. But why do the kettles keep the lid on? Because they do not believe in the deluge. No skill can reach a boy who does not believe in the value of what he is doing. What then is teaching? If teaching means calling out dormant faculties and strengthening minds, it is obvious that pumping indiscriminately on a class, though the veritable waters of Helicon be pumped, is not teaching. Mind is the teacher's subject. He must be able to deal with mind. The first thought of a teacher must be that he has to teach." Thring entertained the idea that if an instructor had no more than twenty-five students, he could have a personal interest in each. He knew that boys are not deficient in ability, but are usually lacking the willingness to learn, and like every genius he had a quickening spirit and could thrill with life dormant faculties. A mere pedant pedagogue could teach rules; he could arouse the whole inner being.

Thring was a thorough believer in what Chalmers called "the expulsive power of a new affection." He emphasized the vast difference between a prison and a school. It is safer to trust boys too much than too little. The prison system of education may produce big blockheads, all of the same dull uniformity, but when lads are loved, and trusted and won, they "can be relied on to do right in sight and out of sight, from having right in themselves." There is only one way to make people lovely and that is to love them. The teacher who is perfectly just can at times be severe, yet retain the affection of his students. The public opinion prevalent in a school can be utilized as a great power in discipline. When there was some misdemeanor, Thring would say, "Now, I am not going to waste words upon A and B. I hold the whole school responsible for these wrong things. Any society can put down offenses, if it chooses." Sometimes when an offense was known to have occurred among the boys of a particular department, all in that section were for a week excluded from the cricket field and compelled to take their exercise walking two and two attended by a master. When anything wrong occurred Thring did not ask "Who did it?" but "Who were there?" The punishment was distributed over the whole section as guilty. He would say, "I don't know who the offenders are, and I don't want to know. They would not have done it, if the rest of you disliked it enough." And thus this model master believed in collective punishment for individual offenses.

Thus all the boys were anxious to prevent misdemeanors, or all would be punished if evil occurred. Public opinion in the school thus became healthy and helpful. With all the force of his being, Thring would denounce every form of cheating, such as the use of a "crib." When anything of the kind was discovered he would say, "A very disgraceful thing has been brought to my notice; two of you have been cheating at work. I mean the school to know what I think of this thing. I hold that to cheat a master is inexpressibly base. I know the mean things you say to yourselves, some of you, in your mean hearts about its being natural to boys, and 'they all do it at other schools,' and the rest of that pitiful talk. But we are not 'other schools.' There have been times when schools were like prisons, and there was some wretched kind of excuse for cheating your jailers. But you don't live in a prison here. We make your life free and pleasant. We trust you. We make it easy to live a true life, and then you turn traitors to truth. Now, which you will! The prison, or the free life of true society." Thus Thring put moral ozone into the atmosphere of the school. To raise individuals he raised the tone of the whole school. He was an athlete and often entered into the sports of the boys. He had a gift of wit. Once when addressing the lads on education he remarked that he would teach them some lessons in matters of discipline illustrated by wood cuts. When some one remarked to him that a certain preacher was dry, "Dry!" exclaimed Thring, "Why, my good fellow, brick-dust is butter to him." Such a master and the boys did not constitute two parties, they were one. His great distinction was that he instituted self-government; by a healthy growth his boys became thoughtful, upright men. Their education prepared them for actual life.

"He made men seers, young dreamers to desire
The one thing good—to do the one thing right;
He cast Truth's heart into the fiercest fight,
And bade us battle and never tire;
He kindled hope, he set dead faith afire,
Gave workers will, filled eyes with love and sight,
And, by the lamp of service, thro' the night
Led learning from the ruts and from the mire.

Not praise nor scorn, not riches, honor, fame,
Could tempt his hand a moment from the plow,
Nor the world-deafening clamor of the daws
Pecking about the plowshare harm his cause;
Let others reap—he claimed to serve and sow—
And as he toiled, the Lord of Harvest came."

—*Education.*

STATUE OF CLAUDE CHAPPE.

We give herewith, from *La Semaine des Constructeurs*, a view of the statue of Claude Chappe erected in the month of July on the Boulevard Saint-Martin, at Paris. The sculptural part is due to Mr. Dame and the architectural part is the work of Mr. G. Farcy.

Chappe was born at Brulon, France, in 1763. In 1791 he conceived the idea of communicating with his absent friends by means of signals. In 1792 he presented to the National Assembly an apparatus which he called a *telegraph*, and which was tried between Paris and Lille, where a dispatch was transmitted through forty-eight leagues in thirteen minutes and forty seconds. The importance of the invention was immediately recognized, and the aerial telegraph soon came into general use.

Before having recourse to optics and aerial signals the idea occurred to Chappe to make use of electricity, but at the epoch at which he accomplished his work, it was not known how to easily produce or manage electric currents. Chappe, who pursued a practical end before all else, therefore contented himself with aerial telegraphy. He foresaw, however, the progress that was to follow and contribute toward transforming all human relations in so wide a limit.

The honor of his discovery having been claimed by others, Chappe's mind was so much affected that he committed suicide in 1805. In raising a statue to him the telegraphers have but rendered justice to one of rare merit and symbolized a lesson of things that skeptics in matters of science and progress would do well to take account of.

It could hardly be imagined, in fact, amid what doubts and obstacles electric telegraphy was born. No scientific tentative has been more bitterly and more conscientiously considered as a chimera by scientists whose authority was capable of crushing it in embryo. The illustrious Arago, whose statue stands at a short distance from that of Chappe, declared peremptorily and imprudently at a session of the Chamber of Deputies on June 2, 1842, that it would be impossible to

STATUE OF CLAUDE CHAPPE, AT PARIS.

think of leaving telegraph wires at the discretion of malefactors. He wished them inclosed in tubes and buried two feet underground.

Pouillet, at the same epoch, said that it was neither proper nor rational to ask for funds for experimenting in electrical telegraphy, and he continued in demonstrating very gently that the latter was a chimera.

These reminiscences do not diminish the merit of Arago and Pouillet, who were active in so many splendid labors with which science has been enriched. But they prove that doubt is sometimes dangerous when the human mind, leaving beaten paths, rushes forward to discovery. It is well not to doubt with a loud voice from the tribune and not to discourage innovators, under the penalty of seeing a very near future put the denial and the fascinating reality of facts in a "deadly parallel."

It is perhaps, moreover, at the very moment when electric telegraphy appears to be reaching the apogee of its perfection, that a new and important progress in this art seems about to modify everything once again. We refer to telegraphy without wires. Just as electric telegraphy made its advent at the moment when the optical methods of Chappe constituted a true system, so telegraphy without wires is certainly, before long, to fell the poles that have for a long time symbolized the transmission of thought to a distance.

This is neither a dream nor a utopia of scientists desiring to go always more quickly and always farther; it is a reality of to-morrow, for telegraphy without wires exists already.

On plunging the two extremities of a wire into the water of a river, it has been possible to communicate from one end to the other as if the line had not been interrupted. During the siege of Paris, Messrs. Bourbouze and Desains, braving the rigor of the terrible winter of 1870, attempted to realize telegraphy without wires by means of the Seine, and obtained some success. Since then the idea has slumbered, but the question has been turned over on every side and studied in its various aspects, while at the same time electricity has progressed and the methods of producing it have been improved. It appears certain that the epoch is near in which two telegraph offices will communicate with each other without wires or cables, from China to Europe, and in which the ship upon the high seas will send news of it at will to its owner. The study of condensers permits of getting a glimpse of this progress at short notice. Now, scarcely twenty years ago, condensers were hardly anything more than a toy of laboratories of physics. They were used for making a few experiments that did not seem to be of very great interest, and one would have doubted the reason of the professor who had predicted that this little instrument would revolutionize telegraphy. This well proves that in scientific matters nothing must be doubted, nothing must be neglected.

CAUSES OF FIRE IN DWELLINGS.

The *Journal* of the Franklin Institute provides an interesting paper upon the "Causes of Fire in Dwellings," in which the author attributes them chiefly to heating and lighting apparatus. Statistics on the causes of fires have been very meager. Strict cleanliness in heating arrangements is urged, as fires are often produced by accumulation of dust and fine organic matter, and before "firing up" in the autumn it is recommended that the entire apparatus be thoroughly examined. Ashes retain heat for a long time, and when seemingly cooled should not be placed in wooden barrels or near frame buildings. Gas fixtures should not be so fixed as to be capable of swinging against combustible substances, such as curtains and woodwork, but should be provided with stops to obviate such danger. Another point often overlooked is that if a window be opened near a gas burner a draught may blow a lace curtain into the flame, and a fire results. The author argues that woodwork near stoves should be protected with bright tin, which acts as a reflector to the heat rays, while a black or rough surface absorbs them. Also that while brick platforms are not so safe as tin, because stoves are not apt to remain as stable upon brick as upon metal, brick arches are the proper means to adopt to protect flooring, and that if brick arches cannot be obtained, then a layer of thick asbestos paper or concrete should be first laid on the woodwork, upon this a layer of sand and concrete, and then bricks laid in good cement, upon which another layer of bricks should be laid, but in such a manner as to leave an air space between it and the preceding course. The safest system of heating, however, he considers to be by hot water, with pipes fixed free from any woodwork. The reason why steam pipes ignite wood he asserts to be twofold—(1) by allowing the water to run low the steam becomes superheated, causing a true combustion, and (2) pipes containing steam at the usual temperature may cause the secondary phenomenon of spontaneous combustion. In the latter case, the steam pipes slowly dry the wood, the contained moisture being vaporized, and at last the wood assumes a state resembling charcoal, whereupon the glowing or combustion, well known in the case of charcoal, takes place spontaneously.—*The Builder.*

IMPROVED PRINTING-OUT PLATINOTYPE PAPER.

A correspondent in *Photography* recommends the following formula:

The paper should first be sized by immersing the sheet in a weak solution of arrowroot and water for four or five minutes. It is then dried and coated with a combination of the solutions as given below.

STOCK SOLUTIONS.

A 1.	
Potassium chloro-platinite	10 grms.
Distilled water	60 c. c.
B 1.	
Ammonium ferric oxalate	40 grms.
Potassium oxalate solution (5 per cent. strong)	100 c. c.
Glycerine	3 "
C 1.	
Iron solution (B 1 as above)	100 c. c.
Potassium chlorate (strength 1 to 20)	8 "
D 1.	
Mercuric chlorate solution (strength 5 per cent.)	20 c. c.
Potassium oxalate solution (strength 5 per cent.)	40 "
Glycerine	2 "

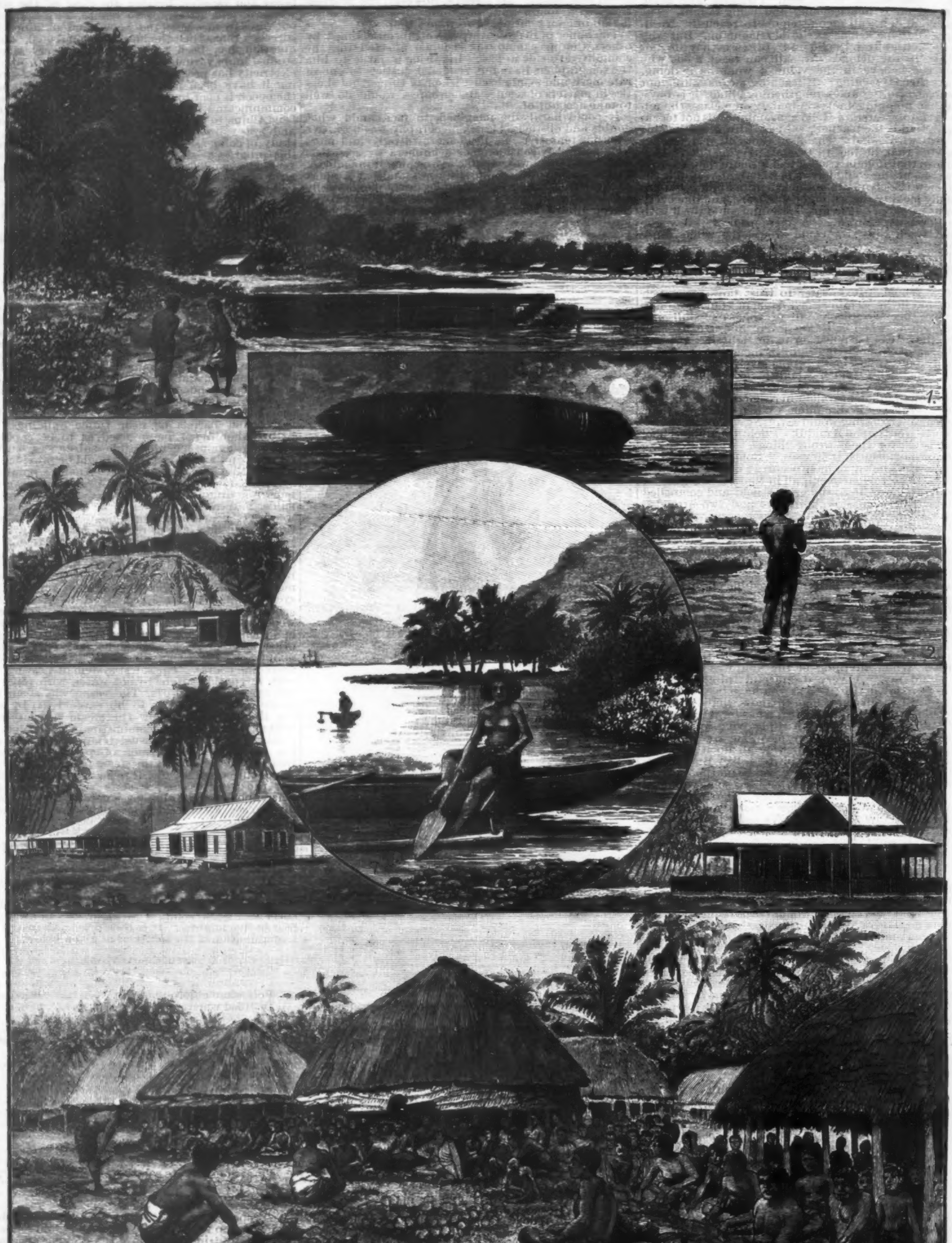
To prepare B 1 the potassium oxalate solution should be heated up to 40° C., and the ammonium ferric oxalate dissolved in it. Upon cooling, some ammonium oxalate will be precipitated. The clear solution should then be filtered off and kept in the dark; to prevent formation of mould add a drop of carbolic acid. To sensitize a sheet (demy size) where *black tones* are desirable, and if negatives of medium density are used, the following proportions should be employed:

Solution A 1	5 c. c.
" B 1	6 "
" C 1	2 "

For harder negatives, the quantity of solution C 1 should be diminished or entirely omitted, the solution B 1 increased to the same extent; in case of softer negatives the reverse is adopted.

VIEWS IN SAMOA.

The Pacific Ocean islanders, though altogether forming not a very large population, and very widely scattered over the greatest space of water on the globe, are frequently talked of by political rumor and controversy; and the Samoa group, latterly the chosen residence of a popular English novelist, Mr. R. L. Stevenson, has been the scene of civil wars and revolutions. Apia, the chief town, is situated in a bay on the north shore of the island of Upolu, with the hill of Vaia, 1,500 ft. high, rising behind it. Half way up this hill is Mr. Stevenson's dwelling. The residences of the native King Malietoa, of Baron Senft von Pilsach, Prime Minister and President of the Municipal Council, and of Chief Justice Cederkrantz, could easily be found by visitors. Two native factions, those of the Laupepa government, at Mulinuu, and of the rival Mataafa, have been fighting some time. The adherents of the latter, coming from the other islands, bring abundant supplies of food, pigs, fowls, yams, grain,



1. Part of the town, seen from the eastern extremity of the harbor. 2. A native fisherman. 3. Residence of Baron Senft von Pilsach. 4 Remains of the German war ship Adler, cast upon the reef by the hurricane of 1888. 5. Hut in which King Malietoa resided. 6. Supreme court. 7. Canoe in Pago-Pago harbor. 8. Meeting of natives presenting food to Mataafa.

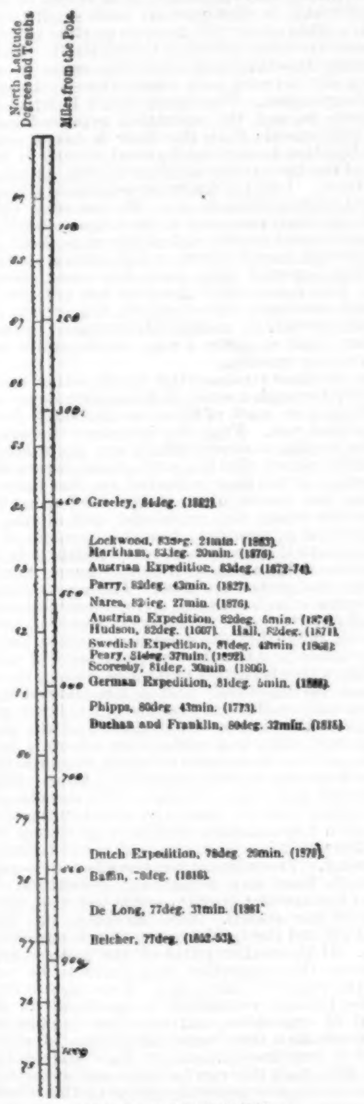
VIEWS IN SAMOA, SOUTH PACIFIC OCEAN.

From the Illustrated London News.

and bread fruit, while the German, British, and American consulates watch the progress of affairs. The United States government is erecting a trade wharf, iron sheds, and workshops in the harbor of Pago-pago. In the bay of Apia lies the wreck of the German gunboat Adler, cast on the reef by the hurricane five years ago.—*Ill. Lond. News.*

THE RACE TO THE NORTH POLE.

DR. NANSEN and Lieut. Peary's expeditions to the Polar regions have served to direct public attention once more to the fascinating subject of Arctic exploration. The accompanying diagram shows the relative positions held by the principal competitors in that race to the North Pole which has been going on for centuries. Sir Edward Belcher in 1852-53 rescued McClure and his crew about sixty miles west of Barrow Strait, and enabled him to make the northwest passage. Commander De Long, who commanded the Jeannette expedition sent out by the *New York Herald* in 1879, to make its way north by Behring Strait, met with disaster. The vessel was crushed in the ice, and De Long and many of his men afterward perished. Early in the seventeenth century Baffin discovered the great northern outlet to the bay which bears his name. In 1878 a Dutch expedition, under Lieutenant Koolemans Beynen, was the first of a series dispatched annually from Holland with excellent scientific results. An expedition was commanded in 1818 by Captain David



The Race to the North Pole.

Buchan and Lieutenant John Franklin in the Dorothea and Trent. Both vessels were injured by the ice and had to return to England. Captain Phipps, afterward Lord Mulgrave, sailed to Spitzbergen, and was detained there by the pack ice for nearly a month before he was able to push further north and reach eighty degrees forty-three minutes. A German expedition, dispatched in 1868, just failed to get as far north as Captain Scoresby, most intrepid of whaling captains, did in 1806. In 1868 a Swedish steamer, the Sophia, reached a latitude of eighty-one degrees forty-two minutes in the month of September. Last year Lieutenant Peary, with the assistance of the Philadelphia Academy of Science, organized an expedition, which, by the discovery of Independence Bay, at a latitude of eighty-one degrees thirty-seven minutes, practically defined the northeastern limit of Greenland. Hudson's achievement in reaching eighty-one degrees thirty minutes, near Spitzbergen in 1607, was repeated twenty-one years ago by Captain Hall, the American explorer, who died during his voyage. An Austria-Hungarian expedition under Lieutenants Weyprecht and Payer sailed from Norway in 1872, and in 1874 Payer discovered a large island about two hundred miles north of Nova Zembla. In 1876 Captain Nares reached eighty-two degrees twenty-seven minutes, thus falling something short of Lieutenant Parry's achievement nearly half a century before; but Captain A. H. Markham, who was a member of Captain Nares' expedition, succeeded by means of sledges in attaining a latitude of eighty-three degrees twenty minutes. Lieutenant Lockwood, who was one of Lieutenant Greely's party, beat Markham by a few miles, reaching eighty-three degrees twenty-four minutes on the coast of Greenland. To Lieutenant Greely, who for the present closes our list, and who with only five surviving companions was rescued at Cape Sabine by Commander Schley in 1884, belongs the glory of having come nearer to the North Pole than any previous navigator in northern seas.—*London Daily Graphic.*

LILIUM LOWII.

FROM time to time the Messrs. H. Low & Co. have brought to light new and interesting plants discovered by their collectors in Upper Burma. Orchids have, of course, been their most numerous finds, and of these mention has from time to time been made in these columns; it is, however, to lilies that attention is now especially directed. The firm has been particularly happy in introducing the new Burmese liliums. Readers will remember the stir which the flowering of Lilium sulphureum, L. primulinum, and L. Lowii caused in 1891, and the subsequent interest with which these species were noted when colored plates appeared in tha *Botanical Magazine*, t. 7,227, t. 7,232, and t. 7,257. L. sulphureum has a long tube, and is, as its name implies, of a pale sulphur yellow. L. primulinum, which is nearly allied to L. Nepalense, has a short tube with revolute segments, and is a dull yellow color. Lilium Lowii is in shape intermediate between the foregoing species and is very distinct in color; the accompanying illustration faithfully represents the shape and character of this fine new introduction. It is reproduced from a drawing made at the recent exhibition of the Royal Horticultural Society held at Chiswick, on which occasion Messrs. Hugh Low & Co. were awarded a first class certificate for a single plant.

The stem of L. Lowii rises to a height of about three feet six inches and is clothed with numerous sessile, linear leaves, from three to four inches in length; about three flowers are produced from the apex, and these have fairly long peduncles. Each bloom is about four inches long and three inches across at the mouth.

LILIUM LOWII.

The color on the outside is white tinged with green, the apical part of each segment is white shaded with yellow, on the inside, while the basal portion is of the same color, but heavily spotted with reddish brown; the midrib widens and becomes more yellow toward the base. This lilium is an elegant species, and much credit is due to the firm whose name it bears for their trouble in introducing it and the other species mentioned into European gardens.—*The Gardeners' Magazine.*

THE SEQUOIAS AT THE AMERICAN MUSEUM OF NATURAL HISTORY.

THE visitor who enters upon the first floor of the old building of the American Museum, in Manhattan Square, New York, where the exhaustive collection of American woods given by Mr. Jesup is exhibited, will pause with astonishment before two enormous wood sections which rise to the ceiling of the room, and might be taken for the cart wheels of some Cyclopean chariot. The larger one of the two measures twenty feet in diameter and has barely accommodated its enormous height to the dimensions of this ample hall. The smaller one, a giant whose size seems only dwindled by comparison with its Titanic companion, is ten feet in diameter, and exhibits a wonderful succession of rings of annual growth which carry the retrospect of the contemplative visitor back to the middle ages.

The large section has not yet been so treated by a fresh sawing across its monstrous girth as to exhibit, in this familiar and interesting way, its marvelous age, but it is reputed to be one thousand years old, and to have commenced its silent growth upward in the groves of California when Charlemagne was king of France. Perhaps the ground through which its opening seedling saw the light was broken by its faint stirrings of life when in the pass of Roncesvalles the chivalry of Charles the Great rolled back into Spain the onrushing hordes of Moslems. Indeed, this bulk of woody tissue holds in the history of its formation the human record of ten centuries.

It may prove to be even older, and should there be discovered fifteen hundred of these concentric alternations of density, which are called annual rings, then indeed the hoary grandeur of its age seems startling. This sequoia would have begun its life when the Christian religion had fairly established itself in Rome, and when Theodosius on the throne of the Cæsars for a time arrested the disintegration of the empire which daily seemed more imminent. The smaller example of these two is the *Sequoia sempervirens*, the redwood which is found in Northern California growing upon the western slope of the Sierra Nevada, where it forms quite dense groves, always within the influence of the sea, whose wet and drenching winds seem to agree with it. This is the true redwood, and is so called because of the dark red color of its wood, while the peculiar fibrous bark, of a rich cinnamon brown, and very thick, forms a distinguishing feature, only imitated by one associated tree, the incense cedar (*Libocedrus decurrens*).

These trees tower to the skies in leafy pinnacles two hundred to three hundred feet high. The trunk rises for almost one hundred feet before it sends out its branches, and the effect of a forest of these straight and lofty columns surmounted by the bright green expanse of their intermingling foliage, through which the light of the upper sky intermittently shines, is very beautiful. They are associated on this Pacific slope with many other noble trees, whose size would mark them for distinction, were not these monarchs of the forest so majestic in their proportions. The Douglas spruce, the sugar pines (*Pinus Lambertiana*) are among these, and form no unworthy company to the towering sequoia. Archibald Menzies, eighty years ago, when surgeon to Vancouver's voyage, collected some old and imperfect cones, which were the first seen by scientific botanists. They were figured by Lambert and described as *Taxodium sempervirens*. But in 1847 Endlicher founded upon it the genus Sequoia, a name supposed to have been derived from *Sequoyah*, a Cherokee Indian of mixed blood, who invented an alphabet and a written language for his tribe.

The larger trunk in the hall, whose section was brought to this city from California in eleven fractions, or sectors, with a central cylindrical bole, has been carefully adjusted by Mr. S. D. Dill, and shows the girth of the tree at a height of twelve feet from the base, where its expanded circumference probably attained a diameter of thirty feet. This is an example of the *Sequoia gigantea*, the great redwood (not properly so called) of Southern California, which is now found in scattered groves, as at Calaveras and Mariposa, at heights varying from four thousand to six thousand feet, in moist hollows and surrounded by less sublime pines and firs. This section, twenty feet in diameter, was taken at Sequoia, King's River, Tulare County, California. These wonderful trees shoot upward in the air some three hundred feet until, as Dr. Gray suggestively remarks of the lofty Eucalypti of Australia, "they might even cast a flicker of shadow upon the summit of the pyramid of Cheops." The *Sequoia gigantea* was only recently revealed to science and became known through an exploring miner in 1852, when it was identified in England from leaves and fruit by Lindley and Hooker as a *Wellingtonia.* Later study revealed its generic separation from Wellingtonia, and a natural patriotism in the Western botanists devised a new genus, *Washingtonia*, for its reception. Later again Dr. Torrey established its identity with *Sequoia*, an Asiatic genus, which was corroborated by Gray, and to it this second and only other species of redwood in our country has been since appropriately referred. It exists in a few separated patches and might have before this succumbed to industrial or money-making enterprises, had not State interference stepped in, and saved these vegetable marvels. One of the tallest of these, "the Keystone State," reaches the height of three hundred and twenty-five feet and its girth at six feet from the ground is forty-five feet.

The present example exhibited to the New York pub-

lic required twenty choppers to prepare its great bulk, and its transportation hither from California required that it should be wedged apart into sections, as only reduced in this way could it be loaded on cars. The pieces arrived successfully, except one, which, after some vigorous search, was discovered and brought on to rejoin its companions, whose united surfaces now form this towering wall of wood before the visitor.

The botanical speculations suggested by these sylvan Titans is not the least interesting aspect of their study. Dr. Asa Gray in his address before the American Association for the Advancement of Science in 1872 epitomized their history and their geographical and structural relations in a very striking way. The *Sequoia* is related to *Taxodium*, of which our bald or deciduous cypress, so familiar to travelers in Florida and well known to our lawns and parks here in the North, is a characteristic representative.

The sequoia of California was first called taxodium, but a distinction obtains in the arrangement of the scales in its cone and in the insertion and succession of its leaves. Now we have no sequoias on the Atlantic seaboard, but the taxodium here takes their place. But in Asia, in Japan and China, there is also a *Glyptostrobus* which is related to the sequoia and the taxodium, "being," as Gray says, "about as much like our bald cypress as one species of redwood is like the other." Again, paleontological research has brought to light the fact that in Europe in the tertiary period all of these genera—taxodium, glyptostrobus and sequoia—flourished. They have disappeared in Europe, but in eastern and western America and in Asia they yet remain, *i. e.*, the taxodium in the Atlantic United States, the sequoia in California and the glyptostrobus in China. A closer scrutiny of their occurrence in these three far-apart stations has shown that in each place they are associated with the genus Torreya, a yew-like tree, and with the true yews as well. Here are three separated groups essentially similar in the juxtaposition of related genera, but fixedly removed from each other by wide intervals of space. How have these striking isolations, with their suggestion of some original unity in place and origin, arisen? Dr. Gray has suggested that these related groups of trees have originated together in the North, and this suggestion has received full confirmation from the discoveries in fossil botany by Heer, Lesquereux, Goeppert, and Newberry. These paleo-botanists have pointed out that in Greenland, Spitzbergen, Iceland, Disco, and Alaska remains generically like sequoia, torreya, taxodium, and glyptostrobus have been found, and that this points to their contemporaneous existence in the northern latitudes at a time when a temperate or subtropical climate prevailed over these frozen regions. Their present separation then has been caused by migration southward along longitudinal lines which, though widely spread asunder at their lower limits, do converge in the North, as though from some primal unity of habitat a geological or meteorological circumstance had permanently dispersed them. What was that circumstance? The ice age. When the great ice cap covered the northern extremity of our hemisphere, these trees had disappeared from their boreal stations, and probably slowly receded as that accumulation of ice and snow was slowly made, until from climatic conditions, variations of soil, and exigencies of seed transportation they have become distributed in their present positions. The wide interval, so far as North America is concerned, between the taxodium, torreya and yew of Florida and the sequoia, torreya, and yews of California may have formerly been partially bridged over by intermediate growths and the then existing links or colonies since obliterated.

These gigantic trees, unique and impressive to-day, assume a fresh interest when we may regard them as the mute index of a terrestrial revolution which buried a circumpolar circle of over forty-five degrees of latitude with ice.

L. P. G.

THE CACAO TREE.

THE cacao, or *Theobroma Cacao*, belonging to the order Malvaceæ, is a tree indigenous to Central America. It is an evergreen and bears flowers and fruit at all times. In days of yore, the Mexicans attributed a divine origin to it and made of it the most beautiful ornament of their terrestrial paradise. Linnæus himself, enthusiastic over the incomparable qualities of cacao, consecrated such origin by giving the different species of cacao trees the generic name of *Theobroma*, "food of the gods."

In 1520, the Spaniards found that the *tchotcolatl* (whence our word chocolate) had been in use since time immemorial in Mexico, not only as food, but also as money. However this may be, cacao was not known in Paris until 1660, and the sale of chocolate was authorized in 1661 by a decree of parliament.

The culture of the cacao tree is particularly difficult. A tropical sun is necessary for it, and it also requires a virgin soil and a humid and burning atmosphere. As it is difficult to find such conditions united, the culture of the cacao tree is relatively limited, despite the repeated efforts of planters, who would like to distribute it throughout the entire intertropical zone.

The fruits of the tree, vulgarly called cacao or cocoa pods, are five-celled and more or less pentagonal, and have a thick, tough, almost woody rind. They are from six to ten inches in length and are marked with ten elevated ribs running lengthwise. Each fruit contains between fifty and a hundred seeds embedded in pulp, and it is from these that the cacao or cocoa is prepared. The color of the ripe fruit is reddish yellow externally and rosy within. The pulp when fermented yields a vinous liquor much sought for by the negroes.

The ripe fruits are split in two by means of a knife and mallet by women and children, who afterward, with a wooden spatula, extract the seeds and a certain quantity of pulp. The mass thus obtained is placed in a heap and left to itself. The pulpy portion soon softens, enters into putrefaction, then liquefies, and, finally, at the end of four or five days, the seeds are completely set at liberty. According to the country, they are then put in heaps or buried in wide and shallow trenches. In both cases, however, they undergo a new fermentation, during which particular care is taken to stir the mass under treatment from time to time, so as to prevent it from heating. After four or five days, this second fermentation is complete, and the seeds are finally dried in the sun upon rush mats.

This fermentation develops the aromatic flavor of the cacao at the expense of the acrid principles that the freshly gathered seeds contain.

The burying of the cacao advantageously modifies its flavor and diminishes its bitterness. So the seeds thus treated are more sought for by the manufacturers of chocolate than those that are treated by exposure to the sun, which are more particularly used for the extraction of cacao butter. However, having once undergone all these treatments, the seed, as white as it was at first, has become a reddish brown. It consists of two parts, viz., the peri-sperm or pod and the embryo or nucleus.

The shell in the dry seed is hard and brittle, smooth or slightly wrinkled. Immediately beneath it is found a very fine white pellicle which completely envelops the nucleus and even enters the folds of its lobes. As for the nucleus, that is formed of two cotyledons having exactly the form of the seed. These cotyledons, which are oily, constitute the edible part of the cacao. At the wider extremity of the nucleus is found the germ, which has lost all its germinative property in the preceding fermentations. This alone serves for the manufacture of chocolate.

To prepare the cacao seeds for use they are roasted in revolving metal cylinders, then bruised to loosen their skins (which are removed by fanning), and the cotyledons, commonly called "cocoa nibs," are afterward crushed and ground between heated rollers, which soften the oily matter and reduce them to a pasty consistence. This pasty material is then mixed with variable amounts of sugar and starch to form the different kinds of cocoa, and sweetened or flavored with vanilla or other substances for the formation of chocolate.

As an article of food cocoa or cacao is exceedingly valuable, from the large amount of nutritive matter that it contains, but as a beverage it is much inferior to either tea or coffee, owing to the large amount (50 per cent.) of fat which it contains, and also to the fact that the whole of the substance is taken into the stomach, while with tea or coffee only an infusion is drunk. It contains a peculiar principle called theobromine, which is an alkaloid analogous to caffeine and answering to the formula $C_7 H_8 Az_4 O_2$. It exists in the nuclei in the proportion of about two per cent. The nuclei contain, on an average, fifty per cent. of a fatty substance known as cocoa butter, which, at the ordinary temperature, is yellowish, shining, and unctuous to the touch. This substance has an agreeable chocolate odor and presents the important property of becoming rancid with difficulty. Hence it is much used in pharmacy.

ARROWROOT MANUFACTURE—ISLAND OF ST. VINCENT.

ARROWROOT (*Maranta arundinacea*) is a native of the tropics. The island of St. Vincent, in the West Indies, has taken the foremost part in its growth and production. A fair quantity is also made in Natal and smaller quantities in India, Fiji, Queensland and other countries. Formerly the Bermuda Islands produced a great deal, but, as there is very little arable land and a scarcity of water, and the inhabitants having turned their attention to growing early vegetables for the New York markets, arrowroot is gradually being given up.

Planting.—In St. Vincent the plant grows two to three feet high. It has a weak fibrous stalk, with six to eight arrow-shaped leaves, resembling the leaves of the lily. When the root is ripe, these leaves fall and wither. The plant flowers, but does not bear seed, and is, therefore, propagated by the root. This can be done in two ways, either by pulling the green stalks, trimming off the long hairy roots and setting them six inches apart in fields previously prepared for their reception, or, as is most generally done, by returning to the soil the upper end of the root, which is hard and fibrous and contains very little starch. As the fields are dug up, the laborers pick out the roots and break off these top pieces four to six inches long, returning them to the soil. In this way reaping and planting go on simultaneously. Care must be taken, however, to avoid returning to the soil small, thin, weak roots. The roots commence to grow in about a fortnight, but to avoid choking the fields, have to be weeded two or three times. In about ten to twelve months the roots are ripe and are then twelve to eighteen inches below the surface. If they are reaped before being properly ripe, the next crop suffers and frequently takes fifteen months to mature and the fields require to be frequently weeded. With careful attention and manuring, fields will produce crops continually. The arrowroot is a very hardy plant, and will continue to grow up and die down for years after its cultivation has ceased in a field. The roots are long and tap shaped, and are jointed at intervals of three-fourths to one inch. In the soil they are protected by a fibrous covering which grows from each joint, the folds overlapping each other to the end of the root. Full grown roots are from ten to eighteen inches long, the most starch being found in the lower or younger end.

Manufacture.—The first part of the manufacturing process is to soak the roots in water to soften the covering and the adhering earth. They are then stripped of the covering and washed and thrown into a second or rinsing tank. When thoroughly clean they are taken to the pulping machine. The skin is said to contain a resinous matter, which gives a yellow tinge and unpleasant flavor to the starch if the latter is not well washed. In former times the roots were very carefully skinned with German silver knives before being pulped. This is said to have produced whiter starch, but as it was so laborious and expensive it was discontinued. The skinned roots were pulped by subjecting them to great pressure by passing them through an upper and then a lower and much closer pair of polished brass rollers to break the starch cells. The method of pulping now generally adopted is to feed the clean unskinned roots against a fine saw grater, very similar to a potato grater. It is a solid cylinder of hard wood about twenty-three inches diameter and seven inches wide. Slits are made by a saw from end to end of the wood at one-half inch intervals. Saw blades having six to ten teeth to the inch are then fitted into the slits and the whole immersed in water to swell the wood and fix the saws. The grater is now fitted into its place very close to a wooden feeding bed. As it revolves several hundred times per minute it tears the roots into shreds. A great deal, however, depends on the fineness of the teeth and the velocity of the drum.

On account of the very fibrous nature of the pulp, there is considerable difficulty in the sieving or separating the starch from it. The fibers readily gather into lumps and inclose the starch, so that hand sieving, although very tedious, has to be resorted to. The pulp is first run into a box or sieve, the bottom of which is a sheet of copper or tin punched with holes about one-fifth inch diameter. While water flows on, the contents are kept thoroughly agitated by hand until all the starch has been washed out. While one strainerful is being washed, another is being filled, so that there should be no delay. However careful one is, there is a loss of starch in the fiber, owing to presence of small bits of the roots which have escaped pulping.

In one factory, instead of the above strainer, a tin-lined copper cylinder has been tried. The cylinder was stationary, its under side being pierced with holes, and inside paddles or beaters revolved at great speed among the pulp and water, until the latter flowed away free from starch. The washed fiber was then removed and a fresh charge of pulp put in. This, however, has been discontinued. In another factory a half cylinder, also stationary, is in course of erection. Its under side is also pierced with small holes, but there is a slide under this to open or close at will. Inside there are rakes attached to two shafts which move in opposite directions and cause the rakes to oscillate very rapidly between each other, thereby keeping the fiber always open. The starch water is let out, more water run in, and the operation repeated until the starch has ceased; then the fiber is taken out. The great objection to any mechanical washer is the tendency of the fiber to accumulate on the agitators and break them. I do not know at present of a single mechanical washer being in use. To get over this difficulty it has been proposed to chop up or slice the roots into small, short pieces, and either rasp them or pass them through metal rollers or mill stones, so that the thin, disintegrated pulp may flow over mechanical sieves. I do not know if this plan has yet been tried. Although causing a loss of starch, the present method of rasping avoids an undue pulverizing of the soft, yellow fiber, and so gives a very white starch without much further trouble.

From the fiber strainers the starch water flows consecutively through a series of brass wire sieves of 40, 80 and 100 meshes; each of these retains small flesh bits of unpulped root. From the last sieve the water runs into the settling cisterns, which are preferably lined with white glazed tiles to avoid accumulation of slime.

A portion of the fiber collected on the finer sieves, and also the coarse fiber, is used for feeding the animals on the estate, the remainder and all the coarse fiber are used as manure. For this purpose it is left in heaps until it decomposes, after which it is distributed on the fields along with pen manure. Sometimes also ashes and guano are used. The waste water from washing the starch contains a considerable amount of vegetable matter, and gives good results where it is run on the fields, but the extensive application of this is not practical. After the starch has settled in the cisterns, the water is run off and more added, the whole is stirred up (optional) and again allowed to settle. This generally suffices to dissolve out soluble matters. At night all the cisterns are drained and the starch is dug out and taken to a mixing box, where it is mixed with about twice its volume of water, then run through another fine sieve into the separating pans. These are small round galvanized cisterns, with smooth perpendicular sides. When filled, the starch milk is stirred round with a round stick until it is in violent circulation. The stick is withdrawn and the cisterns left until morning. The stirring has the effect of separating the starch from any remaining impurities. These, being of less specific gravity, settle last, and, therefore, on top of the starch. Next morning the water is drained off and the light impure starch scraped off the surface. If the earlier parts of the process are carelessly done, this separation may have to be repeated before the starch is quite pure. Even should the separation be perfect, rewashing is beneficial for further removal of vegetable matter. The impure surface starch contains a very large proportion of starch entangled in very fine particles of fiber and broken cell walls. Although this can be dried and exported as an inferior starch, it is generally given to the laborers as a perquisite. It is used in various forms as flour. Poultry and pigs are also fed with it. Weak caustic soda extracts a coloring matter from it, but also precipitates a yellow substance, making it very difficult to separate the starch from it in a pure state. The pure starch in the separators is now taken off in blocks and placed on trays for about twelve hours to drain and harden. It is then broken in smaller pieces and taken to the drying house where it is air-dried. This building is open on all sides for free circulation of air. It is surrounded, however, with galvanized wire to keep out the small birds which hover about. Inside there are wire shelves over large shallow wooden trays. The wet lumps of starch are placed side by side on the top shelf, where they remain until by the action of the air they crack up and fall through on to the next shelf. In time the whole falls through the lowest shelf and is in a fine granular state ready for packing. It contains from fourteen to seventeen per cent. of water. In cold, wet weather the starch dries very slowly, taking sometimes as long as two weeks. During this time, if the starch has been imperfectly purified, or placed too close on the wires, the lump gets sour and becomes yellowish. Indeed the whole process must be as rapid as possible. In the settling cisterns especially, if the starch is left in contact with the impure water too long, its whiteness is affected, fermentation having taken place. The crop lasts from October to May. The name "arrowroot" is I think, derived from the Indian word Ara-ruta, or "mealy root," but some say that this root has been confounded with the *Alpinia Galanga*, which was called the arrowroot on account of its bruised roots being used as an antidote to the poison of the *Jatropha Manihot*, which was used for poisoning their arrows. I may say that tapioca starch is obtained

from this poisonous root. The poison, however, is contained in the juice only, and is destroyed by heat.

Yield.—Regarding the yield of arrowroot, an acre will produce 13,000 to 15,000 pounds of roots, according to the season; in wet seasons the roots are heavy and moist and give less starch. A fair average yield is twenty-two cwt. air-dried starch, with fourteen per cent. water, per acre, or about nineteen per cent. on good roots. I have no doubt that this will be considerably increased by the use of much needed improved pulping and sieving machinery.

Chemical Composition.—The roots that I have analyzed got slightly dried in transit, so that they show a rather high amount of starch. The analysis, however, will give an idea of the constituents of the roots. In some respects it differs from an analysis by Benzon, stated in Ure's Dictionary, and which I append:

	J. W. M.	Benzon.
Starch	27·07	26·00
Fiber	2·83	6·00
Fat	0·26	0·07
Albumen	1·56	1·58
Sugar, gum, etc.	4·10	0·60 (Gum)
Ash	1·23	0·25 ($CaCl_2$)
Water	62·96	65·50
	100·00	100·00

The ash consisted of phosphate of lime and alkaline sulphates, and chlorides.

I have made an attempt to introduce the residual coarse fiber as a raw material for paper manufacture, but consumers say that it is too weak, and lacking in tenacity. For paper making the starch still remaining could be recovered by steeping in boiling water, and used for sizing the finished paper.

Owing to the fall in the value of sugar, the production of arrowroot in the West Indies has been extended rather beyond the demand. The wholesale price has consequently fallen to an almost unremunerative point. This low price, however, will permit it to be used for whatever purposes the commoner kinds of starch are now employed. In some respects it is superior to common starch, and one of my chief objects in writing this paper is to draw the attention of large users of starch to this comparatively new source of very fine starch. Arrowroot swells much more readily and with less heat than maize, rice, or wheat starch, and forms a stiffer jelly. It is, therefore, highly adaptable for sizing and laundry purposes. I think this property is attributable to the larger size of the granules of arrowroot starch, which are among the largest of the starch granules, whereas the granules of wheat, maize, and rice starch are very small, and will contain a greater proportion of starch cellulose and less granulose, the latter being the substance which swells when dissolved in hot water. Another use for which arrowroot starch is very suitable, on account of its great purity and freedom from chemicals, is for the preparation of powder for the skin. Many of the powders sold are composed of very questionable ingredients. Arrowroot well crushed and dried on a plate before the fire is both simple and safe.

It is as an article of food, however, that it has hitherto been mostly used, but the exorbitant retail price put on it (from 8*d.* to 2*s.* per lb.) has kept it out of general use. Of course, being starch, it cannot have the flesh-forming power of flour and other nitrogenous meals, but it is the purest, most digestible and palatable of the starches, and is devoid of the unpleasant taste or flavor observed in potato starch and in the so-called corn flour, and other starches extracted from the cereals by the caustic soda and fermentation processes.

Regarding the annual production of arrowroot, I have not been able to obtain many statistics. Bermuda raises only 500 to 700 kegs, so that very little of what is sold as Bermuda really comes from there. Natal produces 2,000 to 3,000 cases, and St. Vincent about 22,000 barrels, 20,000 of which come to England, and most of the remainder is sent to America.—*Kew Bulletin.*

CACAO.

THERE are four very distinct products that are mixed under the one term cocoa, and which in the minds of very many are all products of the cocoa palm, says the *American Soap Journal.* These are:

Cacao (kah-kow), *Theobroma cacao;* the chocolate berry tree.

Coca (ko-kah), *Erythroxylon coca;* the coca leaf bush.

Coco (ko-ko), *Caladium esculentum, et al.;* the coco roots.

Cocoa (ko-kwah), *Cocos nucifera;* the cocoanut palm.

Of these four, the first and last are best known in northern latitudes, both being very important articles of export from the tropical lands where they are grown; but of all of them there are certain interesting phases that are worthy of mention here.

Cacao, well placed in the genus *Theobroma* (food for the gods), derives its specific name from the Portuguese cacau, which, according to Senor Jesus Sanches, is derived from the Mexican word cacautl, a pure Nahuatl word. It belongs to the natural order *Sterculiaceæ,* is a small evergreen tree, like our apple, growing from fifteen to forty-five feet, is a native of tropical America, but has been introduced into Africa, where it has escaped from cultivation in some localities, and may now be found growing wild. It bears a somewhat egg-shaped pointed pod, furrowed into ten ridges from five to twelve inches long, with a number of seeds buried in a sweet pulp. It is from the seeds that is derived the nutritive fat, about fifty per cent. of the whole, which is used as a food both in the fresh and dried state. Roasted and divested of their husks, they are known as "cacao nibs;" ground into a paste and sweetened and flavored, they yield "chocolate," the most important product of the tree; the nibs alone, either ground, unground, or in a crude paste, yield "cacao," erroneously called in English countries "cocoa." With the oil thoroughly extracted, the dried powder yields "broma;" the husks alone furnish an article known as "cacao butter," which has a chocolate-like taste and odor, and is solid at ordinary temperatures, and is used for soaps, pomatums, suppositories, and like purposes.

THE LUMINIFEROUS ETHER.

AT the anniversary meeting of the Victoria Institute on June 29, Sir G. G. Stokes delivered his presidential address. After a few introductory remarks on the functions of the institute, he said: "I intend to bring before you to-night a subject which the study of light has caused me to think a good deal about: I refer to the nature and properties of the so-called luminiferous ether. This subject is, in one respect, specially fascinating, scientifically considered. It lies, we may say, in an especial manner on the borderland between what is known and what is unknown.

In the study of it, it is quite conceivable that great discoveries may be made, and, in fact, great discoveries have already been made, and I may say even quite recently, and we do not at present know how much additional light on the system of nature may be in store for the men of science; possibly even in the near future, possibly not until many generations have passed away. I will assume what is familiarly known to you all, and what is well established by methods into which I will not enter, that heavenly bodies are at an immense distance from our earth. More especially is this the case with the fixed stars. Their distance is so enormous that even when we take as a base line, so to speak, the diameter of the earth's orbit, which we know to be about one hundred and eighty-four millions of miles, the apparent displacement of the stars due to parallax is so minute as almost to elude our investigation. Nevertheless that distance is more or less accurately determined in the case of a few of the fixed stars. But the vast majority, as we have every reason to believe, are at such an enormous distance that even this method fails with them."

"To give a conception of the immense distance of the fixed stars, I will assume as known that light travels at the rate of about 186,000 miles in one second—a rate which would carry it nearly eight times round and round the earth in that time; and yet if we take the star which, so far as we know, is our nearest neighbor, it would take three or four years for light from that star to reach the earth. Now as we see the fixed stars, there must be some link of connection between us and them, in order that we should be able to perceive them. Probably all of you know that two theories have been put forward as to the nature of light, as to the nature accordingly of that connection of which I have spoken. According to one idea, light is a substance darted forth from the luminous body with an amazing velocity; according to the other, it consists in a change of state taking place, propagated through a medium, as it is called, intervening between the body from which the light proceeds and the eye of the observer. For a considerable time the first of these theories was that chiefly adopted by scientific men. It was that, as you know, which Newton himself adopted; and probably the prestige of his name had much to do with the favorable reception which for a long time it received. But more recent researches have so completely established the truth of the other view, and refuted the old doctrine of emissions, that it is now universally held by scientific men that light consists in an undulatory movement propagated in a medium existing in all the space through which light is capable of passing."

"This necessity for filling all space, or at least such an inconceivably great extent of space, with a medium, the office of which, so far as was known in the first instance, was simply that of propagating light, was an obstacle for a time to the reception by the minds of some of the theory of undulations. Men had been in the habit of regarding the inter-planetary and inter-stellar space as a vacuum, and it seemed too great an assumption to fill all this supposed vacuous space with some kind of medium for the sole purpose of transmitting light. Notwithstanding, even long ago strong opinions were entertained to the effect that there must be something intervening between the different heavenly bodies. In a letter to Bentley, Newton expresses himself in very strong language to this effect: 'That gravity should be innate, inherent and essential to matter, so that one body may act upon another at a distance through a *vacuum,* without the mediation of anything else, by and through which their action and force may be conveyed from one to another, is to me so great an absurdity that I believe that no man who has in philosophical matters a competent faculty of thinking can ever fall into it. Gravity must be caused by an agent acting constantly according to certain fixed laws; but whether this agent be material or immaterial, I have left to the consideration of my readers.'"

"What the nature of the connection between the earth and the sun, for example, may be whereby the sun is able to attract the earth and thereby keep it in its orbit—in other words, what the cause of gravitation may be—we do not know; for anything we know to the contrary, it may be connected with this intermediate medium or luminiferous ether. There are other offices, we believe, which this luminiferous ether fulfills, to which I shall have occasion to allude presently."

"In connection with the necessity for filling such vast regions of space with this medium, a curious question naturally presents itself. We cannot conceive a space as other than infinite, but we habitually think of matter as occupying here or there limited portions of space, as for example the different heavenly bodies. The intervening space we commonly think of as a vacuum, and it is only the phenomena of light that led us in the first instance to think of it as filled with some kind of material The question naturally presents itself to the mind, Is this ether absolutely infinite like space? This is a question to which science can give no answer. Though we cannot help thinking of space as infinite, yet when we turn our thoughts to some material existing in space, perhaps we more readily think of it as finite than infinite. But if the ether, however vast the portion of space over which it extends, be really limited, we can hardly fail to speculate what there may be outside its limits. Space there might be wholly vacuous, or possibly outside altogether this vast system of stars and ether there may be another system subject to the same laws or subject to different laws, as the case may be, equally vast in extent; and if there be, then so far as we can gather from such phenomena as are open to our investigation, there can be no communication between that vast portion of space in part of which we live and an ideal system altogether outside the ether of which we have been speaking."

"But the properties of the ether are no less remarkable than its vast or even possibly limitless extent. Matter of which our senses give us any cognizance is heavy, that is to say, it gravitates toward other matter which agrees with it in so far as being accessible to our senses. The question presents itself to the mind, Does the ether gravitate toward what we call ponderable matter? This is a question to which we are not able to give any positive scientific answer. If the ether be in some way or other connected with the cause of gravitation, it would seem more likely that it itself does not gravitate toward ponderable matter."

"Again we have very strong reason for believing that ponderable matter consists of ultimate molecules. First, that supposition accords in the simplest way with the laws of crystallography. Chemical laws afford still stronger confirmation of the hypothesis, through the atomic theory of Dalton, now universally accepted. Comparatively recently, the deduction of the fundamental property of gases from the kinetic theory, as it is called, affords strong additional confirmation of that view of the constitution of matter. Still more recently the explanation which has been afforded by that theory of that most remarkable instrument the radiometer of Crookes has lent further confirmation in the same direction. None of these evidences apply to the ether, and accordingly we are left in doubt whether it too consists of ultimate molecules, or whether on the other hand it is continuous, as we cannot help conceiving space to be."

"The undulatory theory of light was greatly promoted in the first instance by the known phenomena of sound, and the explanation which they received from the hydrodynamical theory. Accordingly, since sound, as we know, consists of an undulatory movement propagated through the air (or it may be through other media), and depending upon condensation and rarefaction, it was supposed naturally that light was propagated in a similar manner, by virtue of the forces brought into play by the condensation and rarefaction of the ether. But there is one whole class of phenomena which have actually no counterpart in those of sound; I refer to polarization and double refraction."

"The evidence for the truth of the theory of undulations as regards the phenomena of common light depends in great measure upon the fact of interference and the explanation which the theory gives of the complicated phenomena of diffraction. But in studying the interference of polarized light, additional phenomena presented themselves which ultimately pointed out that the vibrations with which we are concerned in the case of the ether differ altogether in their character from those which belong to sound.

The phenomena of the interference of polarized light prove incontestably that there exists in light an element of some kind having relation to directions transverse to that of propagation, and admitting of composition and resolution in a plane perpendicular to the direction of transmission according to the very same laws as those of the composition and resolution of forces, or velocities, or displacements in such a plane. This requires us to attribute to the ether a constitution altogether different from that of air. It points out the existence of a sort of elasticity whereby the ether tends to check the gliding of one layer over another. Have we no example of such a force in the case of ponderable matter? We have. We know that an elastic solid, which for simplicity I will suppose to be uncrystalline, and alike in all directions, has two kinds of elasticity, by one of which it, like air, tends to resist compression and rarefaction; while by the other it tends to resist a continuous gliding of one portion over another, and to restore itself to its primitive state if such a gliding has taken place. There is no direct relation between the magnitude of these two kinds of elasticity, and in the case of an elastic solid such as jelly the resistance to compression is enormously great compared to the resistance to a gliding displacement."

"If we assume that in the ether there is really an elasticity tending to restore it to its primitive condition when one layer tends to glide over another, an elasticity which it appears to be absolutely necessary to admit in order to account for the observed laws of interference of polarized light, the question arises, Can we thereby explain double refraction?"

"The earliest attempts to explain it in accordance with the theory of transverse vibrations were made by attributing to the ether a molecular constitution more or less analogous to that which we believe to exist in ponderable matter. Following out speculations founded upon that view, the celebrated Fresnel was led to the discovery of the actual laws of double refraction; the theory, however, which he gave was by no means complete, inasmuch as the results were not rigorously deduced from the premises. Cauchy and Neumann, independently and about simultaneously, took up Fresnel's view of the constitution of the ether and applied it to explain the laws of double refraction."

"In their theory the conclusions arrived at were rigorously derived from the premises; but the results did not altogether agree with observation; that is to say, although they could by the adoption of certain suppositions be forced into a near accordance with the observed laws of double refraction, yet they pointed out the necessity of the existence of other phenomena which were belied by observation. Our own countryman Green was the first to deduce Fresnel's laws from a rigorous dynamical theory, although nearly simultaneously MacCullagh arrived at a theory in some respects similar, though on the whole I think less satisfactory."

"Still all these theories followed pretty closely the analogy of ponderable matter; and at least in the first three mentioned the ether was even imagined to consist of discrete molecules, acting on one another, like the bodies of the solar system regarded as points, by forces in the direction of the joining line, and varying as some function of the distance. I have already quoted the very strong language in which Newton rejected the idea of the heavenly bodies acting on one another across intervening spaces which were absolutely void.

But the conception has nothing to do with the magnitude of the intervening spaces; and the conception of action at a distance across an intervening space which is absolutely void is not a bit easier when the space in question is merely that separating two adjacent molecules, when the ether is thought of as consisting of discrete molecules, than it is when the space is that separating two bodies of the solar system, though in this latter case it may amount to many millions of miles. If the ether be in some unknown manner the link of connection whereby two heavenly bodies are enabled to exert on one another the attraction of gravitation, then according to the hypothetical constitution of the ether that we have been considering, we seem compelled to invent an ether of the second order so to speak, to form a link of connection between two separate molecules of the luminiferous ether. But since the nature of the ether is so very different as it must be from that of ponderable matter, it may be that the true theory must proceed upon lines in which our previous conceptions derived from the study of ponderable matter are in great measure departed from."

"If we think of the ether as a sort of gigantic jelly, we can hardly imagine but that it would more or less resist the passage of the heavenly bodies—the planets, for instance, through it. Yet there appears to be no certain indication of any such resistance. It has been observed indeed, in the case of Encke's comet, that at successive revolutions the comet returned to its perihelion a little before the calculated time. This would be accounted for by the supposition that it experienced a certain amount of resistance from the ether. Although at first sight we might be disposed to say that such a resistance would retard perihelion passage, yet the fact that it would accelerate it becomes easily intelligible, if we consider that the resistance experienced would tend to check its motion, and so prevent it from getting away so far from the sun at aphelion, and would consequently bring it more nearly into the condition of a planet circulating round the sun in a smaller orbit."

"Many years ago I asked the highest authority in this country on physical astronomy, the late Prof. Adams, what he thought of the evidence afforded by Encke's comet for the existence of a retarding force, such as might arise from the ether. He said to me that he thought we did not know enough as to whether there might not possibly be a planet or planets within the orbit of Mercury which would account for it in different way. But quite independently of such a supposition, it is worthy of note that the remarkable phenomena presented by the tails of comets render it by no means unlikely that, even without the presence of a resisting medium, and without the disturbing force arising from the attraction of an unknown planet situated so near to the sun as not to have been seen hitherto, the motion of the head of a comet might not be quite the same as that of a simple body representing the nucleus, and being subject to the gravitation of the sun and planets and nothing else. It appears that the tails consist of some kind of matter driven from the comet with an enormous velocity by a sort of repulsion emanating from the sun. If the nucleus losesin this manner at each perihelion passage an exceedingly small portion of its mass, which is repelled from the sun, it is possible that the residue may experience an attraction toward the sun over and above that due to gravitation, and that possibly this may be the cause of the observed acceleration in the time of passing perihelion, even though there be no resistance on the part of the ether. So that the question of resistance or no resistance must be left an open one."

"The supposition that ether would resist in this manner a body moving through it is derived from what we observe in the case of solids moving through fluids, liquid or gaseous, as the case may be. In ordinary cases of resistance, the main representative of the work apparently lost in propelling the solid is in the first instance the molecular kinetic energy of the trail of eddies in the wake. The formation of these eddies is, however, an indirect effect of the internal friction, or if we prefer the term viscosity, of the fluid. Now the viscosity of gases has been explained on the kinetic theory of gases, and in the case of a liquid we cannot well doubt that it is connected with the constitution of the substance as not being absolutely continuous, but molecular. But if the ether be either non-molecular, or molecular, in some totally different sense from ponderable matter, we cannot with safety infer that the motion of a solid through it necessarily implies resistance."

"The luminiferous ether touches on another mysterious agent, the nature of which is unknown, although its laws are in many respects known, and it is applied to the everyday wants of life, and its applications are even regulated by acts of Parliament; I allude to electricity. I said that the nature of electricity is unknown. More than forty years ago I was sitting at dinner beside the illustrious Faraday, and I said to him that I thought a great step would have been made if we could say of electricity something analogous to what we say of light, when we affirm that light consists of undulations; and he said to me that he thought we were a long way off that at present. But, as I said, relations have recently been discovered between light and electricity which lead us to believe that the latter is most closely connected with the luminiferous ether."

"Clerk-Maxwell showed that the ratio of two electrical constants which are capable of being determined by laboratory experiments, and which are of such a nature that that ratio expresses a velocity, agrees with remarkable accuracy with the known velocity of light. This formed the starting point of the electro-magnetic theory of light which is so closely associated with the name of Maxwell."

"According to this idea, light may be looked on as the propagation of an electro-magnetic disturbance, whatever the appropriate idea of such a thing may actually be. The theory has quite recently received remarkable confirmation by the investigations of Hertz, who has shown that what are incontestably electro-magnetic disturbances, and are investigated by purely electrical means, exhibit some of the fundamental phenomena of light, such, for example, as interference and polarization. It appears that these electro-magnetic waves are strictly of a similar nature to the waves of light, though there is an enormous difference in the scale of wave lengths, which in the case of light range about the [illegible] part of an inch, while the electro-magnetic waves which have been investigated by purely electrical methods range from a few inches to many yards."

"I have ventured to bring this interesting subject before you in the course of the address which I have just delivered. I have not attempted to lay before you the evidence on which scientific men rely for the truth of the conclusions which I have mentioned as well established. That would have required, not merely an evening address, but a whole course of lectures. Neither have I made any allusion to possible bearings of the scientific conclusions on questions relating to religious beliefs. Anything of that kind I leave to your own minds; my object has been simply to present to you very briefly the conclusions of science in that limited branch which I have selected, distinguishing as impartially as I could what is well established from what is debatable or even merely conjectural."

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